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the small systems journal

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SIMULATION

Inside Apple

Vol. 1, No. 4

A dot matrix printer that will improve your image.

Meet the Apple® Imagewriter, the newest dot matrix printer for your Apple Personal Computer.

And with all that it has going for it, just maybe the best dot matrix printer on the market.

Take legibility, for instance.

The Imagewriter crams 140 x 160 dots into each square inch. So you get text that's highly readable and high resolution graphics, besides.

And is it fast.

The Imagewriter cruises at an unbelievable 120 characters per second. And that's just in the text mode. It's even faster printing graphics. 180 characters per second, to be exact.

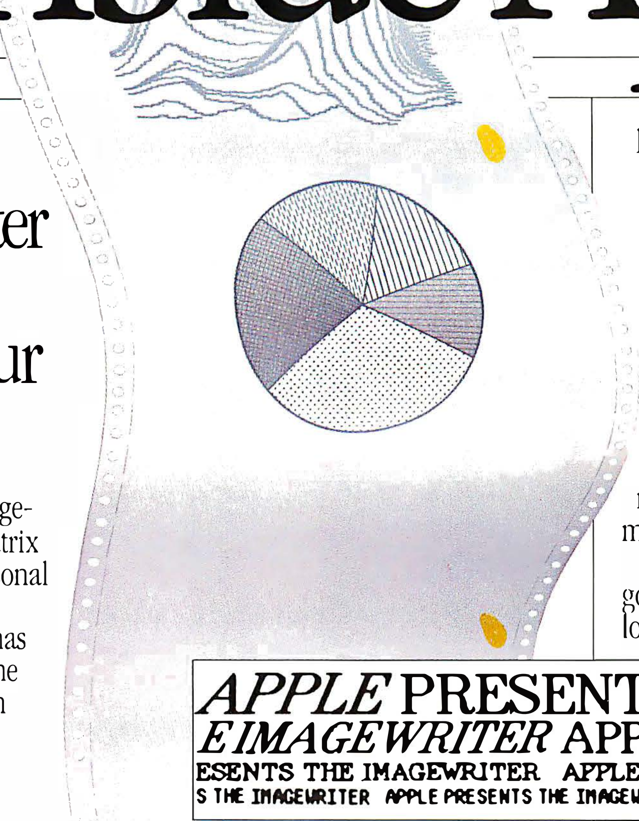
What's more, the graphics dump is up to 60% faster than other comparably priced dot matrix printers. And that makes the Imagewriter fast enough to handle the Lisa.™

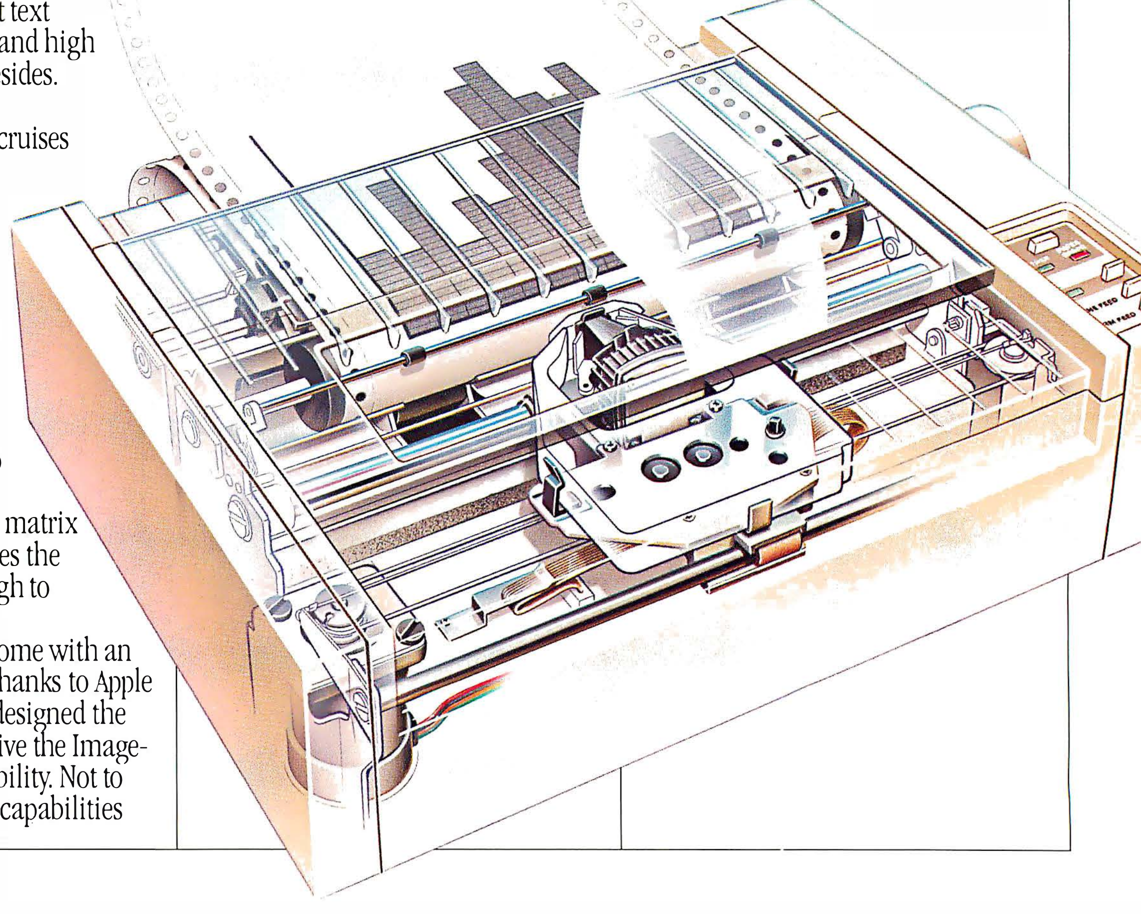
Yet it's just as at home with an Apple III or Apple IIe. Thanks to Apple software experts who designed the control electronics to give the Imagewriter perfect compatibility. Not to mention some special capabilities like superscript and subscript, to name just two.

Now, with all this high-speed performance, you'd expect the Imagewriter to make the Devil's Own Noise. It doesn't. In fact, the Imagewriter is specially constructed — with overlaid seams and special sound-deadening materials — to achieve a remarkable 53 dB. How loud is a remarkable 53 dB? You'd make more noise if you read this aloud.

The Imagewriter even has quiet good looks, since we designed it to look like the rest of the Apple Family.

Yet even with all its improvements, the Imagewriter is a better deal than any other dot matrix printer with comparable performance. And you can print that.







Charge!

Go out there and get the Apple Personal Computer System you really want. Now. Without laying out your extra cash. Without tying up your other lines of credit. With the Apple Card. The only consumer credit card reserved exclusively for the purchase of Apple Computers, peripherals and software.

Like all our products, it works simply:

Fill out an application (short, to the point and annotated in English) at an authorized Apple dealer honoring the Card. Your salesperson will call in the application and in most cases get an approval for you right on the spot.

You can then take your Apple system home. You don't even have to wait for the Card; we'll mail it out to you. And by the time you get it, you'll probably be well into doing whatever you bought your Apple system to do.

There is no annual fee for the Card, although a couple of restrictions do apply. The first purchase must include an Apple Personal Computer and you have to put 10% down. And subsequent purchases need to be at least $100 if made with the Card. Oh, yes — you'll also have a credit limit.

When you use the Apple Card to make additional purchases, all you have to do is show the Card and sign the invoice. As long as it's within your credit limit, of course. Our dealers get a little nervous when someone signs for half their inventory. You understand.

You'll also receive monthly statements that include the latest purchases, credit available, and the minimum payment due. You'll also be happy to know Apple Card credit terms are affordable and the payments can be spread out. It's all spelled out for you at the time your Card is approved.

So stop by a participating authorized Apple dealer and get an Apple Card. Just think of it as credit where credit is due.

Give your floppy disks the boot.

We call it the "floppy disk shuffle." It happens when you have two or more software programs on floppies and you need to work with both. What do you do? You put one disk in, boot it, do your work, take it out, put the other disk in, boot it, do your work — you get the idea.

Well, you can stop shuffling any time now.

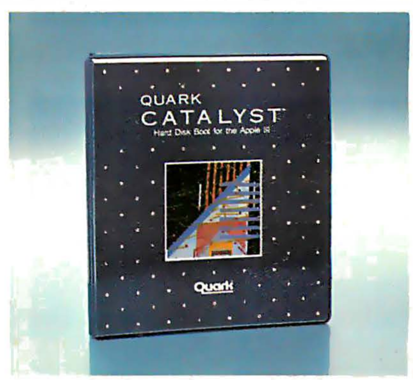
Thanks to a unique new software program called Catalyst™ from Quark, Inc. Specially designed for your Apple III and ProFile™ hard disk.

Catalyst allows you to take a wide variety of software programs and store them on your ProFile. Once they're on your ProFile, you just select the program you want from the Catalyst menu that appears on your monitor — then Catalyst does the rest. You'll never have to boot those programs again.

What kinds of programs will work with ProFile and Catalyst? Almost anything written for the Apple III including copy-protected programs like VisiCalc,® Quick File™ and Apple Writer III. Or languages like Pascal, BASIC, or COBOL.

And once you've loaded these programs into your ProFile, the only diskette you may ever need is the Catalyst.

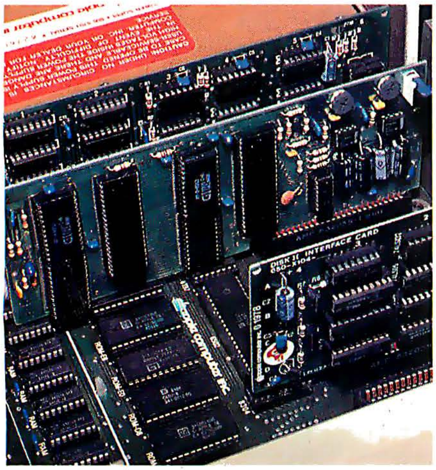
So if you have an Apple III and a ProFile and more floppies than you care to flip through, get yourself a Catalyst. And boot those disks for good.



Apple Computer Inc., 20525 Mariani Ave., Cupertino, CA 95014. For the authorized Apple dealer nearest you, call **(800) 538-9696.** *In Canada, call* **(800) 268-7796** *or* **(800) 268-7637.** *© 1983 Apple Computer Inc.*

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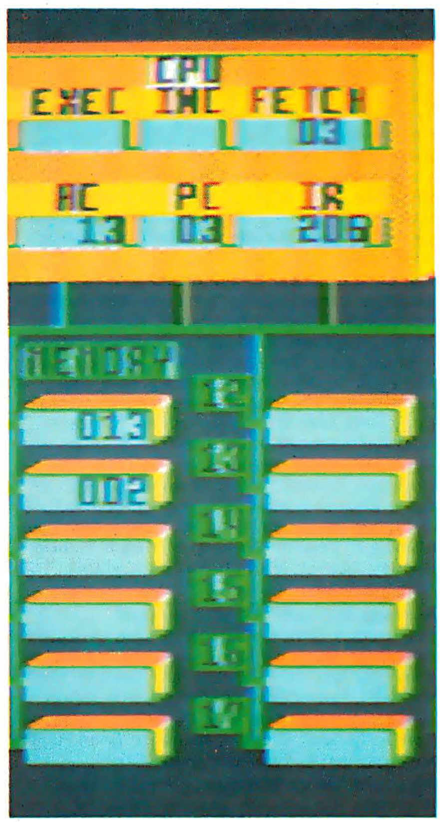
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Editorial

Where BYTE Is Going

We want to clear up some confusion about different kinds of articles in BYTE that have sometimes been mistaken for one another, to explain how we intend to avoid the same problem in the future, and to reaffirm BYTE's editorial direction as a magazine for personal computer users.

BYTE publishes *reviews* in order to help readers make purchasing decisions on personal computers, peripherals, and software. A review passes judgment on a product. Every review in BYTE appears in the Reviews section and carries a banner that includes the word "review." Although staff members sometimes write reviews, we more often solicit them from personal computer users who are not on staff. We try to ensure that reviews are thorough, frank, and fair. Fairness requires that all reviews be performed on actual shipping products rather than prototypes or beta-test machines and software. To do otherwise is unfair to the reader, the reviewer, and the manufacturer. In a few cases, we have mistakenly published reviews of prerelease products. (We owe an apology to Supersoft for holding a prerelease version of its C compiler up to the standard of a shipping product in our August 1983 issue.)

BYTE publishes *product descriptions* to give readers an early look at forthcoming products that are innovative and important. BYTE staff members write almost all product descriptions because of the absolute confidentiality required in gaining access to prototypes and beta-test products months before product announcements. Because product descriptions are written at such an early stage of a product's development, they cannot pass judgment on the final product. Rather, the goal of a product description is to give the reader as much technical information as possible at the time and also a detailed impression of how it feels to use the product, how the product works, and how it breaks new ground.

When we see a prototype or test system at an even earlier stage of development, we call the resulting article a *product preview* rather than a product description. Again we try to give our readers an early look at something new and interesting, and an impression of the product-to-be, but we also recognize that the manufacturer may make significant changes before going into production. A product preview usually has less detail than a product description.

To review a prerelease product would be unfair, but product descriptions and previews do point out design limitations that cannot be changed by shipping date (for example, the HP 150's lack of provision for an 8087 coprocessor, or Macintosh's lack of an inboard second disk drive). At this writing, BYTE has done product previews of both the HP 150 and the Macintosh, but has not yet received review machines of these products. As soon as machines arrive, we will assign them to reviewers. We will publish the reviews as quickly as possible after their completion, but bear in mind that a good review requires the writer to use a product for four to eight weeks and then spend another two weeks or more in the writing. It takes another three to four months to turn a completed manuscript into a printed article in BYTE.

Those readers who have recently suggested that BYTE publishes too many favorable reviews have typically mistaken product previews and product previews and product descriptions for reviews. The editors of BYTE are under no pressure to review any product favorably. We enjoy complete editorial

How Cromemco plugs you into the state of the art.

Cromemco offers you the most complete line of S-100 boards and peripherals in the business. These boards use the new IEEE-696 state-of-the-art standard. One-stop shopping can satisfy your design needs the easy way.

You can build one system, or a hundred, exactly the way you want, and upgrade existing systems with a simple board swap or addition. And since we design our own boards for our own systems, we always take advantage of the latest developments in IC technology.

68000 microprocessor performance. Cromemco's Dual Processor Unit gives you the best of both worlds: the 68000 and the Z-80A microprocessors on the same board. It's the easiest way to move into 68000 performance and still use your existing 8-bit software. Or use Cromemco's Z-80A CPU board or our Z-80A-based single board computer.

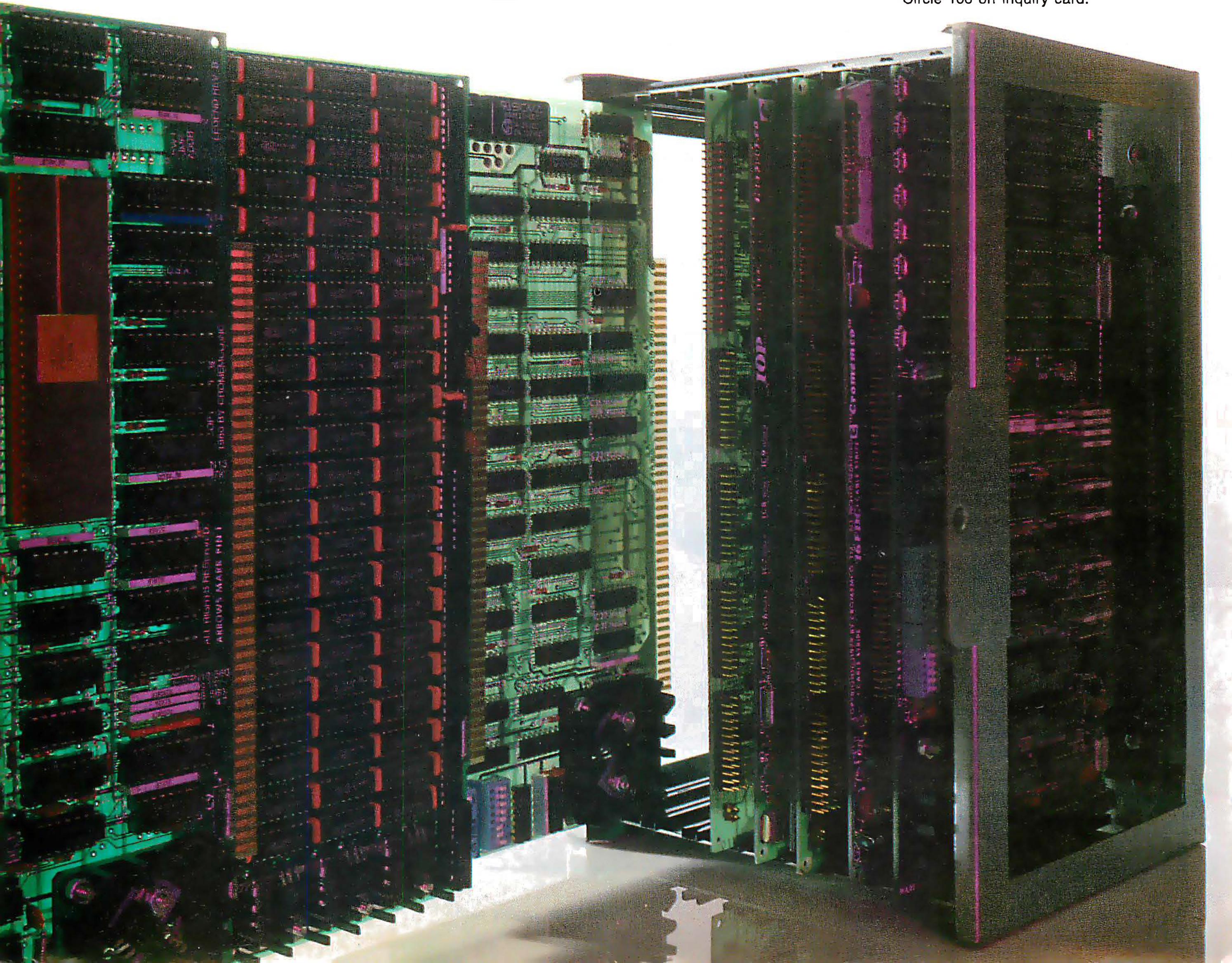
For selection, Cromemco can't be matched. From the well-known SDI High Resolution Color Graphics board to the new 512MSU, 512K byte RAM board. From our highly reliable Local Area Network interface (C-NET) to our wide variety of general purpose interface boards. And you can put them in one of our 8-, 12-, or 21-slot card cages with our 12 amp PS-8 power supply to get your system into operation fast.

We have over 30 S-100 boards to fill your needs. And all are supported by a broad line of software. Our Board Products Catalog has the latest information. Call today for your copy, or to get the name of our nearest dealer or distributor. Or, write Cromemco, Inc., 280 Bernardo Avenue, P.O. Box 7400, Mountain View, CA 94039. Tel: (415) 964-7400. In Europe: Cromemco A/S, Vesterbrogade 1C, 1620 Copenhagen, Denmark.

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Cromemco

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freedom, which remains unabridged even when advertisers have canceled ads because they disliked a review.

BYTE does sometimes accept articles from the designers or developers of some interesting new product or technology but never asks or permits them to review their own creations. We publish design and development articles because they can appear months earlier than reviews, can contain insights into technical creativity, and can provide a glimpse of the state of the art or the future direction of personal computing.

In some recent cases, BYTE has been guilty of insufficient editorial zeal in purging promotional material from certain articles. We deeply regret these errors, are correcting the circumstances that led to them, and will redouble our efforts to see that no expressions of self-interest appear in these pages. We definitely erred in moving the affiliations of authors from the beginning of the article to the end. The change was made for purely graphical reasons, not to mislead the reader, and is reversed in the April issue. In upcoming issues we will also provide distinctive graphics to make reviews, product descriptions, product previews, and design articles look markedly different from one another.

We try our best to present independent reviews of all products covered in design articles, product descriptions, and product previews. This has been the case with the June 1983 issue on "16-Bit Designs," which attempted to show the great variety of systems becoming available despite the tide of PC compatibles and to stimulate dialogue between designers and users. In a few instances, circumstances prevented our publishing in-depth reviews of products featured in that issue. Four of the systems described—Gavilan, Sunrise, Pronto, and TI 99/2—had hardly been announced and could not have been reviewed then. Unfortunately, we are still awaiting review machines of the Gavilan, the Sunrise (Xerox 1800), and the Pronto. The TI 99/2 *died* aborning but was of interest as an under-$100 16-bit computer. Despite these exceptions, most of the systems presented in the June issue have been reviewed or are scheduled for review in the near future. Berry Kercheval's independent review of the HP Series 200 Model 16 appeared in November. (Generally he liked the machine, but he found serious fault with the documentation, the keyboard, and the Pascal compiler. David Colver, in turn, found Kercheval's review wanting, and we publish Colver's letter on page 15 in this issue.) Reviews of the DEC Professional 350, the Altos 586, the Fujitsu Model 16s, and the Sritek 68000 board for the IBM PC are in progress. A review of the DEC Rainbow is scheduled to appear in April.

This issue contains product descriptions of the Tandy 2000 and the IBM PCjr. Reviews will follow as soon as possible; we would be delighted to receive reviews from any readers who get one of the first production machines from Tandy or IBM.

In some areas of advanced technology, such as perpendicular magnetics, there is not yet a product to describe, preview, or hand over to an independent reviewer. Furthermore, it is extremely difficult to find an expert author who is not working for one of the few companies active in that field.

BYTE is committed both to covering new technology in depth and to providing independent, well-informed, frank, and fair product reviews. Although we will seek technical expertise in academe, industry, and private life, BYTE is and will remain a magazine for personal computer users. The sophisticated user is both our most common reader and our best writer. We believe that users should shape the future of personal computing, and we invite you once again to do so through the pages of this magazine.

—Phil Lemmons, Managing Editor

HOW TO GET AN IBM® PC FOR JUST $1995.



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The Chameleon by Seequa does everything an IBM PC does. For about $2000 less than an IBM.

The Chameleon lets you run popular IBM software like Lotus® 1-2-3™ and Wordstar.® It has a full 83 key keyboard just like an IBM. Disk drives like an IBM. And a bright 80 × 25 character screen just like an IBM.

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So if you've been interested in an IBM personal computer, now you know where you can get one for $1995. Wherever they sell Chameleons.

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Get A HeadStart™ On The Other Guys.



HeadStart Features:

Size: 15" wide, 11" deep, 10½" high.

Weight: 25 lbs.

Processors: Z80A (8 bit) and 8086 (16 bit).

Memory: 128K to 1MB depending on model. All models are expandable.

Disk Storage: 500K to 1MB (unformatted) on a 3½" Micro-Disk.

Display: 12" (diagonal) P31 phosphor, non-glare screen, 25 lines x 80 or 132 columns.

Keyboard: Detachable with 105 total keys. Also an optional portable version straps onto the front screen area for easy transportability.

Disk Operating Software: *CP/M 80 for 8 bit. **MS DOS for 16 bit. LAN DOS for multi-user 8 or 16 bit operation.

Networking: Up to 255 HeadStart VPUs may be connected via coaxial interface into one of 2 optional data storage systems.

Interfaces: One RS449/RS232 compatible serial port. One Centronics compatible parallel printer post. External data bus. Coaxial communications interface. External disk I/O interface.

Optional Data Storage Systems: 2 models available. A 10MB, 5¼" system is expandable to 20MB. A 50MB, 8" system (25MB fixed, 25MB removable) is expandable to 200MB.

*CP/M is a registered trademark of Digital Research.
**MS DOS is a registered trademark of Microsoft.

Intertec's HeadStart is the smallest, smartest, fastest, most powerful business computer money can buy.

And the most expandable (it's networkable up to 255 user stations.)

Great Ideas Come In Small Packages.

Instead of three bulky components, HeadStart needs only two—the keyboard and CRT. There's no need for a cumbersome disk and processor cabinet. With HeadStart, it's all in the CRT enclosure.

HeadStart's small but powerful 3½" disk drive offers as much storage as larger 5¼" disks. Its 8 *and* 16 bit processors make software availability no problem.

And HeadStart's small size permits easy transportability with no sacrifice in performance. Each Video Processing Unit (VPU) comes with its own easy-carrying handle. A portable keyboard option is also available.

How Fast Is Fast?

HeadStart's RAM Disk, an electronic emulation of the typical second internal drive, responds up to fifty times faster than conventional microcomputers.

Depress a key and you get a response within a split second. Literally before your finger leaves the key.

And HeadStart is incredibly powerful, too. Up to one megabyte of internal memory can tackle even the most sophisticated applications.

Some Ideas Are Bigger Than Others.

Because HeadStart is designed to be both a single *and* multi-user computer, you buy only as much computer as you need today.

But as your business grows, it grows with you.

Each HeadStart Video Processing Unit comes with its own memory, processors, disk and multi-user interfaces.

Just add a 10 or 50 megabyte Data Storage System and up to 255 users can share a common data base in an incredibly powerful, multi-user network.

HeadStart is available in three different models. All offer full performance, transportability, and are easily expandable.

Unlike conventional, single-user-only computers, HeadStart is here today with the designed-in technology to be here tomorrow.

So get a HeadStart on the other guys. For more information, call (803) 798-9100 or write: Intertec, 2300 Broad River Road, Columbia, SC 29210.

intertec™

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MICROBYTES

Staff-written highlights of late developments in the microcomputer industry.

SINCLAIR ANNOUNCES 68008-BASED BUSINESS COMPUTER

Sinclair Research Ltd. introduced in England a low-priced computer using a 68008 processor. The 68008 is an 8-bit data bus version of Motorola's 16-bit 68000. The QL (for "quantum leap") computer will include 128K bytes of RAM, two 100K-byte tape drives, two local-area network ports, two RS-232C serial ports, SuperBASIC, and a multitasking concurrent operating system. It will sell for £399 (about $570) through mail order in England.

Bundled with the machine will be QL Abacus, a spreadsheet package; Archive, a database manager; Easel, graphics software; and Quill, a word processor. While the company may add a hard-disk interface, it has no plans for a floppy-disk drive. Sinclair hopes to bring the QL to the U.S. late this year.

LOTUS ANNOUNCES NEW INTEGRATED SOFTWARE PACKAGE

Lotus Development Corp. has introduced an integrated software package including word processing, database management, telecommunications, spreadsheet, and graphics capabilities. Lotus says the spreadsheet portion is compatible with 1-2-3 and has enhanced graphics and macro capabilities. The program lets you display multiple windows simultaneously, even into a single document. Lotus says the new product will be available in the summer.

SEIKO OFFERS WRISTWATCH-DISPLAY COMPUTER

Seiko Electronics and Instruments Co. of Tokyo has developed a microcomputer that uses a 4-line by 10-character LCD display on a wristwatch. In addition to normal watch and alarm functions, the $85 watch includes 2K bytes of CMOS RAM and 6K bytes of ROM and has four cursor and function keys. A separate 62-key keyboard, which will cost about $26, uses wireless electromagnetic induction to transmit information to the watch.

A $127 Z80-based controller can be used with the keyboard and watch to program in BASIC, to interface with a printer, and to use ROM cartridges that Seiko plans to offer. The controller's Microsoft BASIC is not compatible with MSX or any other version of BASIC. With an optional interface adapter, not yet released, the computer can use an RS-232C interface for communications. Seiko began selling the UC-2000 series products in Japan last month and may offer them in the U.S. later this year.

KOALA PAD MAKER ADDS LIGHT PEN TO LINE

Koala Technologies Corp. announced at the Winter Consumer Electronics Show (CES) that it will manufacture and distribute the Gibson Light Pen for Apple, IBM, and Commodore microcomputers. The $300 pen can be used to draw high-resolution color animation, shapes, and graphs directly on a CRT screen using the Pentrack Language System and Penpainter software, which are included.

RADIO SHACK MODEL 100 GETS DISK DRIVE, MONITOR

Radio Shack has introduced a disk drive and video interface for its Model 100 notebook-size computer. The Disk/Video Interface includes one 184K-byte 5¼-inch floppy-disk drive, with room for an optional second drive, as well as an interface for a standard video monitor or television set. Model 100 disks will not be compatible with other disk formats. The video interface displays 25 lines by 80 characters on a monitor (25 by 40 on a television display) and supports the full Model 100 character set, but it cannot use Model 100 dot graphics. The Disk/Video Interface will sell for $799; an optional second disk drive is $239.95.

COLECO'S ADAM TO GET DISK DRIVE, MODEM, AND OTHER ADD-ONS

Coleco Industries Inc. announced a variety of add-on products for its Adam computer system at CES. The products, which should all be available by late summer, include a 300/1200-bps modem for less than $250, a second digital data-pack (cassette) drive for under $200, a 64K memory expander for under $200, and a tractor-feed option for the Adam's printer for about $125.

Coleco also announced a 5¼-inch double-sided, double-density disk drive with a 360K-byte capacity for less than $400. Included with the disk drive—or available separately on a digital data pack—will be Digital Research's Personal CP/M operating system, making Coleco the first U.S. manufacturer to use this home computer version of CP/M.

A TOUCHSCREEN AND NEW COMPUTERS FROM COMMODORE

Commodore Business Machines Inc. showed a touch-sensitive screen and supporting software at CES, similar to the Hewlett-Packard Model 150's touchscreen. The screen should be available in late spring at a "not very high" price.

Commodore also showed its new 264 series of computers. Features include 64K bytes of RAM, windowing, 128 colors, two tone generators, and a machine-language monitor. The 264 will be available in several versions, each with different ROM-based applications software. Available software includes 264 Magic Desk, a combination calculation and filing program using icons for mode selection; 264 Word Processor; and 264 3-Plus-1, an integrated package including a spreadsheet, word processor, file manager, and graphics. Prices for the 264, which will be available in early summer, were not announced.

NEW ADD-ONS FOR APPLE II AND MACINTOSH

Apple Computer Corp. is shipping its new ProDOS operating system with all Apple II disk-drive packages; it is available separately for $40. Apple also unveiled a $700 protocol card to allow Apple II computers to emulate IBM 3270 and 2780 terminals. A $300 terminal-emulation package is also required.

Apple is selling modems that connect to the RS-232C serial port of any Apple product except the original Apple II: a 300-bps modem is $225; a 1200-bps version is $495.

A number of third-party vendors unveiled products for Apple's new Macintosh computer. Most are translations of software available for the Apple II or IBM PC, including IBM terminal emulation, accounting, game, and business-productivity software. Included are Microsoft's Multiplan, Word, Chart, and File programs, and Lotus Development Corporation's popular 1-2-3 spreadsheet program. As for hardware products, Tecmar Inc. has announced a 5-megabyte removable cartridge hard-disk drive, and Davong Systems Inc. has introduced a line of 5- to 32-megabyte hard-disk systems for the Macintosh.

UNIX PRODUCTS ANNOUNCED AT UNIFORUM SHOW

The peak of February's Uniforum show in Washington, D.C. was an agreement between AT&T and Digital Research Inc. to publish a library of applications software for UNIX System V in an effort to make that version of UNIX a standard. Software approved by DRI and AT&T will be sold by both companies. According to AT&T, over 90 companies have published over 300 programs for UNIX so far.

AT&T also announced enhancements to UNIX System V and demonstrated its Documentors Workbench and a version of BASIC for software developers to run under UNIX.

Whitesmiths Ltd. showed a $550 version of IDRIS, its UNIX-like operating system, for the IBM Personal Computer.

NANOBYTES

Despite strong efforts by a number of microcomputer-based chess programs, this year's World Computer Chess Championship was led by mainframe-based programs. In winning the title, Cray Blitz, a program running on a Cray supercomputer, defeated AT&T Bell Labs' Belle, which is classified as a "master" chess player, and Northwestern University's Nuchess. . . .**Harris Semiconductor** is sampling the 80C88, a CMOS version of Intel's 8088 microprocessor to be available late this year. Harris already is producing the 80C86. CMOS microprocessors use far less power than NMOS versions, allowing use in portable computers and industrial and military applications. . . .**Sony Corp.** is reportedly developing a version of its double-sided 3½-inch disk drive that can store 5 megabytes of information. . . .**Hitachi** has reportedly developed a one-megabit memory chip. . . .**Select Software** has introduced Select Bilingual, a $395 word processor able to give prompts and display text in both Spanish and English. . . .**Microsoft** and **National Semiconductor** announced that Microsoft's XENIX, an implementation of UNIX, will be available for National Semiconductor's 16032 processor. . . .**Commodore, Coleco,** and **Epson** have signed agreements with CompuServe, which will provide special information services for owners of those computers. . . .**Epson America Inc.** will sell a $795 MS-DOS expansion card for its Z80-based QX-10 computer, with 256K bytes of RAM and an 8088 processor. . . .**Creative Software** has announced three integrated software packages for the Commodore 64 and the IBM PC and PCjr. Priced at $49.95 each are: Joe's Writer, a word processor; Fred's Filer, an index card file; and Jack's Calc, a spreadsheet package. . . .**IBM** is now selling PC/IX, a $900 version of UNIX System III, through its National Accounts and National Marketing divisions.

Introducing COMPAQ PLUS, the first high-performance portable personal computer.

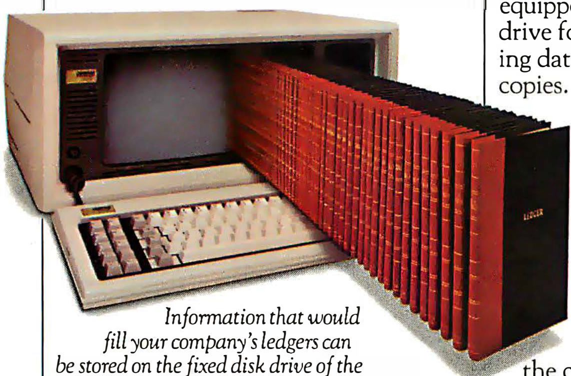
The makers of the COMPAQ™ Portable Computer, the industry standard, announce another breakthrough—the COMPAQ PLUS™ Portable Personal Computer. No other personal computer can handle so much information in so many places.

The new COMPAQ PLUS offers the power of an integrated ten-megabyte fixed disk drive in a portable. You get problem-solving power that no other personal computer can match.

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How much is ten megabytes?

Enough to tackle jobs that can't be conveniently handled on most personal computers.



Information that would fill your company's ledgers can be stored on the fixed disk drive of the COMPAQ PLUS.

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The fixed disk drive keeps all the information seconds away, ready to be searched, sorted, retrieved, analyzed or updated.

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The integrated fixed disk drive will store programs. That means your most used programs and data can be permanently kept in the COMPAQ PLUS, ready to call up and run.

With programs permanently stored, the COMPAQ PLUS becomes a well-informed traveling companion, a tool to help you apply your best thinking anytime, anywhere.

You could store a complete library of accounting programs on the disk—payables, receivables, general ledger, and payroll—*with* the company's books.

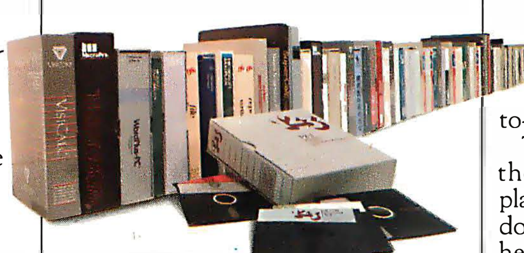
You could store an inventory control program with your inventory records and a list management program with your mailing list and a filing program with your personnel files.

The COMPAQ PLUS is also equipped with a 360K byte diskette drive for entering new programs, copying data files, and making backup copies.

Plus more programs

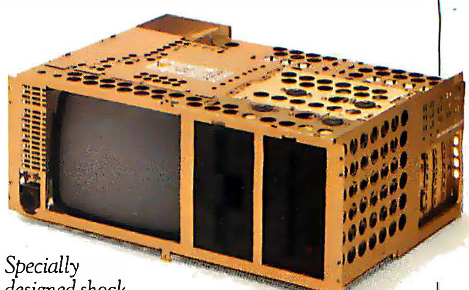
More programs means more versatility. And the COMPAQ PLUS is impressively versatile because it runs all the popular programs written for the IBM* Personal Computer XT, available in computer stores all over the country. And they run as is, with no modification whatsoever.

And the high-capacity portable multiplies the productivity of every program it runs. Your inventory and its control programs can go with you to the factory. Your books and your accounting programs can go with you to a board meeting. Your building specs and your project management programs can go with you to the construction site.



The COMPAQ PLUS runs all the popular programs written for the IBM Personal Computer XT.

You're buying a computer to solve problems. Why not have more problem-solving programs to choose from?



Specially designed shock isolation system protects the fixed disk from jolts.

Plus a traveler's toughness

Life can be tough on the road. A true portable has got to be tougher. The COMPAQ PLUS is.

Its integrated fixed disk drive is unique, designed specifically to travel. Rough roads and hard landings don't bother it because of a specially designed shock isolation system that protects the disk from jolts and vibration.

All the working components are surrounded by a uniquely cross-membered aluminum frame. This structure, common in race car design technology, strengthens it side-to-side, front-to-back, and top-to-bottom.

The outer case is made of LEXAN*, the same high-impact polycarbonate plastic used to make bulletproof windows and faceplates for space suit helmets.

Does a portable personal computer really have to be this tough? Take a good look at your briefcase and then decide.

Plus ease of use

The COMPAQ PLUS is big where it counts.

The display screen is big. Nine inches diagonally. Big enough to show a full 25-line-by-80-character page that's easy to read even if you're leaning back in your chair.

The keyboard is full-sized and typewriter-style for easy control.

With its built-in display, the COMPAQ PLUS makes a smooth, low profile on your desk, not an obstacle that you have to talk around.

Plus an easy way to get started

If you're buying your first personal computer and you're not sure how much capacity you need, your choice is easier now.

Start with the COMPAQ Portable with single or double 320K byte diskette drives. If you need more capacity later, upgrade to the COMPAQ PLUS. A conversion kit is available that turns the COMPAQ Portable into a COMPAQ PLUS, complete in every detail and capability.

Plus a lot more

The COMPAQ PLUS also works with optional printers, plotters, and communications devices designed for IBM's personal computer family.

It has two IBM-compatible slots for adding optional expansion boards. With companion programs, they'll let you share information with a network of personal computers in your office, communicate with your headquarters computer files while you're away, or add memory capacity if your needs grow.

The COMPAQ Portable, the industry standard in portable personal computers. ▼

The problem-solving power of a high-performance desktop personal computer can now go where you need it.



It's got high-resolution graphics and text on the same screen. A detached keyboard. Programmable function keys. Expandable memory. Dozens of other features that simply make it do a better job of personal computing.

And when you see all that the COMPAQ PLUS has to offer, you'll be pleasantly surprised by the price. The fact is, it costs hundreds less than comparably equipped desktop personal computers.

See the first high-performance portable personal computer. The COMPAQ PLUS—performance, programs, productivity. Plus problem-solving power.

The new COMPAQ PLUS, the first high-performance portable personal computer. ▼

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- ☐ One integrated 10-megabyte fixed disk drive
- ☐ One 360K byte diskette drive.

Software
- ☐ Runs all the popular programs written for the IBM XT.

Memory
- ☐ 128K bytes RAM, expandable to 640K bytes

Display
- ☐ 9-inch diagonal monochrome screen
- ☐ 25 lines by 80 characters
- ☐ Upper- and lowercase high-resolution text characters
- ☐ High-resolution graphics

Interfaces
- ☐ Parallel printer interface
- ☐ RGB color monitor interface
- ☐ Composite video monitor interface
- ☐ RF modulator interface

Expansion board slots
- ☐ Two IBM-compatible slots

Physical specifications
- ☐ Totally self-contained and portable
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Letters

Common Concern

I share the doubts and concerns of your correspondents (Letters, page 12, November 1983) about your use of articles describing new products contributed by employees of the manufacturer involved. I was particularly disappointed by the June 1983 issue on 16-bit designs, which seemed largely composed of such material. However, there are deeper and more disturbing aspects involved than your correspondents have noted.

In this country, Hewlett-Packard has been promoting its 68000-based model 9816 computer with mail shots and advertisements in trade publications using the slogan "a lion packaged as a housecat," attributing the phrase to BYTE. These words begin and conclude the description of the 9816 authored by an HP employee ("Tight Squeeze: The HP Series 200 Model 16," June 1983, page 110).

I telephoned the HP representative in charge of the sales campaign and told him of my misgivings about the use of wording that gave the impression that an independent BYTE review had drawn this favorable conclusion. His answers were surprising.

He told me that the article was too professionally written to have been the work of an HP engineer, so that a staff writer must have ghost-written it, and it was thereby a BYTE article regardless of the attribution to HP; that BYTE would not have published it if they had disbelieved it; and that BYTE had been contacted by HP and had given consent for the promotion in question. Nevertheless, he apologized if HP had unintentionally appeared to mislead.

I would like to see your version of this story in print. If HP, one of the most reputable firms in the business, can manipulate BYTE in this way, then you owe it to your readers to prevent less-scrupulous operators from doing the same.

You might argue that the independent review of the 9816 ("A Look at the HP Series 200 Model 16" by Berry Kercheval, November 1983, page 328) should tend to verify or counterbalance the manufacturer-submitted descriptions. I use the HP machines professionally, and I can only remark how disappointing this review is.

HP BASIC is one of the best BASICS around and is unusual in having separate subroutines and functions. How can a serious review illustrate this language with a three-page listing of a game program, written as one large routine? Should not potential purchasers be warned of a significant shortcoming in the system, that the file-handling software can be very slow unless used with care and understanding? Why are independently compiled modules that borrow much syntax, power, and elegance from Modula-2 and are the core concept of the Pascal implementation, mentioned in just a few lines, whereas several paragraphs are devoted to explaining that you can't play a tune on the bleeper?

Perhaps publishing the maker's description is not such a bad idea after all.

David Colver
29 Chepstow Place
London, England W2 4TT

Mr. Colver's letter is representative of several BYTE has received in the past few months. This month's editorial (see page 4) addresses in detail the issues raised by these letters.

As to the specifics of Mr. Colver's letter, no BYTE editor had any role in the authorship of the June article on the HP 200-16. John Monahan of Hewlett-Packard wrote the article, as indicated when the article was published. The purpose of the theme articles in the "16-Bit Designs" issue was to show the views and intentions of people who are designing today's personal computers, in the hope of starting more direct communication between computer designers and computer users. None of the articles on 16-bit designs was a review or was labeled as a review. (This is not to disclaim BYTE's responsibility; see the editorial for more on this.)

Permission for HP's use of the quotation from Mr. Monahan's article was granted by telephone. BYTE is now developing new procedures to prevent the misleading use of quotations.

Praise for Objectivity

I bought my first computer in November 1982 and am still pleased with it. I am a writer, not a computer expert. I read everything I can find on computers. My friends, with whom I compare notes frequently, own IBM PC, PC-compatible, Kaypro, Apple, and Zenith computers. We do not put each other down, and we are not fooled by magazine authors who haughtily demean products they consider to be inferior.

Almost every article we read in computer publications is biased. The author has a prejudice from his or her long experience in computers and selects facts to prove the prejudice. I don't believe that the proponents of Apple, IBM, Kaypro, etc., intentionally misuse their vast knowledge to confuse us. I think, however, that they are lazy about objectivity—almost all of them.

BYTE is far and away the best of the computer magazines I have read, and I now subscribe to 10. After today, I will subscribe to only three, BYTE included.

On such subjects as what computer companies are going to do, magazines should stick with excellent interviews with corporate executives who know what they're talking about, such as your interview with Philip D. Estridge of IBM (November 1983, page 88).

Magazines enjoy predicting that many of the hundreds of computer companies are going to go out of business. How many magazines are going to fold as a result of sloppy editing, shallow reporting, and childish biases?

Maintain your dignity. Continue to avoid the prejudicial comparisons that make other magazines look foolish. We all know that all of our computers have good points and weak points. We didn't buy mainframes.

Robert R. Jann
3320 Selwyn Ave.
Charlotte, NC 28209

Software Design Resources

Martin Dean laments the dearth of articles on "how to design software" ("Simplify, Simplify, Simplify," December 1983, page 161). I'd like to point out some papers that may be helpful:

- A case study of how a design evolved iteratively in response to user feedback is described in "A Communications Package for the IBM PC" by R. Moore and M. Geary (November

1983 BYTE, page 199).

- The design principles for an office-system user interface are described in "Designing the Star User Interface" by D. Smith et al. (April 1982 BYTE, page 242).
- A pattern-directed approach to database query language similar to Dean's is described in the paper "Query by Example" by M. Zloof (*Proceedings of the National Computer Conference, 1975*, page 431).
- A general scheme of "filtering templates," with the specific example of an information retrieval program called Findit, is described in the paper "A Metaphor for User Interface Design" by A. Goldberg and D. Robson (*Proceedings of the 12th Hawaii International Conference on Systems Sciences, 1979*, page 148).

I agree with Dean that finding useful descriptions of the design process is hard (even harder than finding papers on good designs themselves), but I don't think this is due to a "plot." Many commercial software developers carefully guard their designs, but there is still a tremendous amount of published literature from academia, research labs, and "enlightened" commercial developers. Thorough research of this literature pays off: one ends up either with a body of existing ideas on which to build, or with knowledge of the existence of an area in which few have thought (or written).

Paul McJones
Tandem Computers Inc.
2116 Kramer Ln.
Austin, TX 78758

A Scalpel Icon?

I must commend Tom Houston for his article entitled "The Allegory of Software" (December 1983, page 210). He brought up a point that is all too frequently glossed over by "user-friendly" software enthusiasts. I believe the main point of his article was that it is better to train people to use software than to write sophisticated software that condescends to the level of a 10-year-old.

I will agree that much of the software that has been written is not very good from the user's point of view. This is usually because the input and output sections of the program were written by people whose major skill was programming and not what is now called human-factors engineering. As a result, the program could be cumbersome to use. The answer to this problem, however, is programs that are efficient to use, not programs that are easy to use.

Systems based on the idea of metaphors run more slowly and use more memory than systems designed by a standard approach such as menus or commands. Moreover, they are only useful for inexperienced users. A person who has had enough experience with any particular program will be able to use it as efficiently as a novice with a user-friendly system.

No computer system can do the real work that a professional is paid to do. Anyone who spends a good proportion of his life learning what to do with a computer should be willing to spend about one-thousandth of that time learning how to use the computer itself. If a program is well designed, learning how to use it will pay off more in the long run than using "metaphorical" software that is almost a type of crutch.

One might say that the development of user-friendly software was predicted as early as 1950 in a science-fiction story by Cyril Kornbluth, entitled *The Little Black Bag*, in which the author described a futuristic surgical kit with which a complete idiot can practice medicine (trick: the scalpels do all the work). I would recommend this story to those involved in developing easy-to-use systems because it gives a frightening glimpse at what can happen if the development of technology takes precedence over the development of intelligence in people, a.k.a. "education."

Paul B. Callahan
701 Stuart Hall
University Park, PA 16802

IBM Drive Door Fixes

Had I authored "Buddy, Can You Spare a Door Latch?" (by Jerry Pournelle, December 1983, page 59) about the elusive door latch for the Tandon drive, the article would have been subtitled, "Whence Cometh the Door Latch."

My experience with the doors on the drives in my IBM PC has been that the plastic guide pins shift, causing malpositioning and jamming of the doors.

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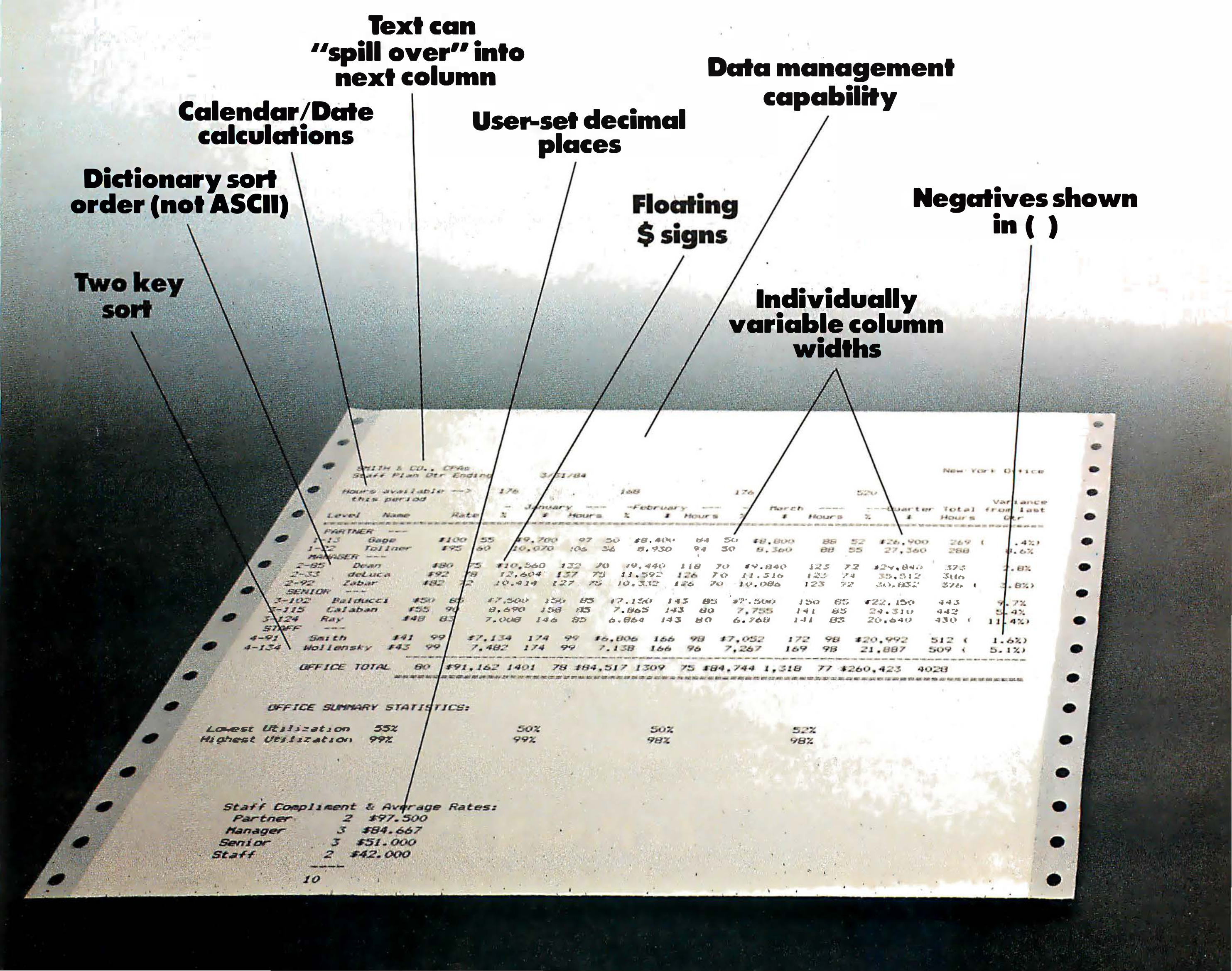
At first, all spreadsheets seem to give you about the same things. Until you put them to work. Then you'll find out if they do everything you expected. Or make you do everything the hard way.

You know what makes the difference? It's not just having the newest, whizziest features, but what those features actually do for you in the real world. And that's the whole idea behind SuperCalc and SuperCalc2. Because they've been designed to work with you in a natural, intuitive way.

What we're really talking about here is useability. When you get right down to it, it's not any one big thing, but a combination of little things. Like the number of keystrokes it takes to get a job done. Or the effort it takes to switch from one function to another. Maybe a few keystrokes here and there doesn't seem like much of a difference. Or having to change disks to plot a graph. But when you multiply those little things by the thousands of times you do them, they make all the difference in the world.

Even the size of the spreadsheet is important. Some programs promise you a huge area to work with. Unfortunately, they can use so much of the computer's available memory just keeping track of all the blank cells that you're left with only a handful. But we've designed SuperCalc to give you the largest useable spreadsheet.

If you look at the printout below, you'll see a lot more examples of what we mean. And we think you'll realize why this is the most useable spreadsheet in the world.



My first "fix" was to reposition the pins and doors and everything worked fine until the next slippage/jam. My second fix mimicked the first with the addition of a carefully applied drop of a superglue penetrating adhesive where the plastic pins are held in two slots on either side of the door.

Eventually one door itself broke, not the pins. My first try at a replacement part was successful. A visit to my local Computerland store, a short discussion with their "Mr. Fixit," a brief rummaging through a box marked "Parts for Tandon Drives" and, voilà, a small box marked "IBM Office Products Division, 8529260, 1PCLC 2 83" had just the right part in it.

My total investment of time and effort was about 1.5 hours: 10 minutes for the initial phone call to determine the likelihood of success if I visited Computerland, a 1-hour round-trip drive to pick up the part, 20 minutes or so to get into the PC, remove one or two screws, and change the pesky door.

I hope that this note will help those with similar problems to (a) try doing it yourself, it's an easy replacement job, and (b) have an easy time getting the part through (I presume) any IBM dealer or Product Center. In a call to the IBM Product Center in Stamford, Connecticut (just before mailing this note), I learned that the part is indeed available, although not in stock at the center. Delivery would be less than two weeks and the company representative with whom I spoke implied that IBM could expedite and foreshorten that delivery if the part is critical to the customer.

Donald P. Relyea
Hoffrel Instruments Inc.
POB 825
South Norwalk, CT 06854

Looking Over the Rainbow

A note on Rich Malloy's "Reviewer's Notebook" (December 1983, page 282). I was for a brief time a distressed owner of a DEC Rainbow 100. My impression of this machine, after about 50 hours of intensive use, was quite the opposite of Mr. Malloy's. It struck me as the handsomest, most expensive smart terminal ever made. I ended up returning the unit for a refund after a DEC support person agreed with my criticisms:

1) The documentation is wretched, though slickly produced. In some instances, two documents contradict each other on the same point. No useful information is provided on screen formatting or using the function keys. An additional set of documents is available for about $250 extra. DEC informed me that there was no way I could get a look at these documents without purchasing them.
2) There is no high-level language support of screen formatting or function keys. By trial and error I figured out how to simulate PRINT AT and so forth. But why should I have to? Why is there no LOCATE statement in the Microsoft BASIC? I could not figure how to use the function keys at all. DEC's advice was to buy the $250 documents and program the softkeys in machine code. Again, after spending nearly $4000 on a "system," why should I have to code

my own routines for such a rudimentary function? Obviously, DEC expects the end user *only* to buy packaged software.

3) DEC advertises that its dual processors can run "thousands" of extant CP/M and CP/M-86 disks. Not so. Because DEC has chosen a perverse disk format (single-sided quad-density, 98 tpi) and has shut out third-party vendors by an "authorization" program, the *only* software available for the Rainbow is what DEC approves and sells. This amounts to dozens, not thousands, of programs.

When BYTE does a full-bore review of the Rainbow, I hope you will address these points. I am convinced that my criticisms are valid, by my experience, by the concurrence of the DEC support person, and by the sudden plummet of DEC's stock after the Rainbow was introduced—attributed by a DEC spokesperson (in *The New York Times*) almost wholly to the personal computer division.

I think DEC rushed into the market with a handsome but immature product. In a year or two the Rainbow may be a good, solid, general-purpose microcomputer. At the moment it's a collage of impressive features with limited utility.

Carter Scholz
2110 Acton, #2
Berkeley, CA 94702

A review of the Rainbow is scheduled for April.

IBM Screen Displays

Many thanks to Tim Field for supplying the screen listing (the program for switching of monitors on the IBM PC). Other than some minor comment errors, the listing was bug-free and worked great the first time around ("Enhancing Screen Displays for the IBM PC," November 1983, page 99). This was my first try at assembly-language programming and I found this program useful in developing a feel for the power and flexibility this method of programming offers for functional control.

As pointed out by Mr. Field, the default values for initial conditions can be modified to suit the individual user. I find that starting with the monochrome screen rather than the color monitor, and white characters on a black background are more natural initial states. This startup condition can be achieved by modifying three lines in the listing as follows:

```
LINE 0112: CUR_MODE
    DW MONO_AREA
LINE 011A: COL80_AREA S
    <5019H,000FH,20H,3>
LINE 0122: COL40_AREA S
    <2819H,000FH,10H,1>
```

Line 012A remains unchanged; although the comment indicates the attribute to be reverse video, this is not the case. For reverse video the 0007h value should be 0070h.

Again, due to its ability to remain active under all operating modes, and its ease of implementation, this program is far superior to any of the other monitor-switching programs I have seen.

Sig Hansen Jr.
6530 Happy Canyon Rd.
POB 125
Santa Ynez, CA 93460

Thanks to Tim Field for his article "Enhancing Screen Displays for the IBM PC" (November 1983, page 99).

One small detail should be pointed out to readers: the file, after assembling, should be converted to .COM by using the Exe2bin program. I spent a whole day trying to get it to work, and because the last paragraph of the article states that you can buy an installation program, I thought I was ripped off.

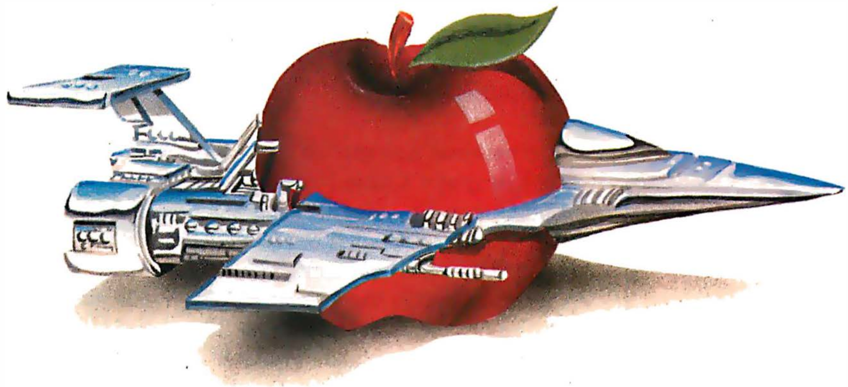
Many thanks again for an "It's just what we needed" program.

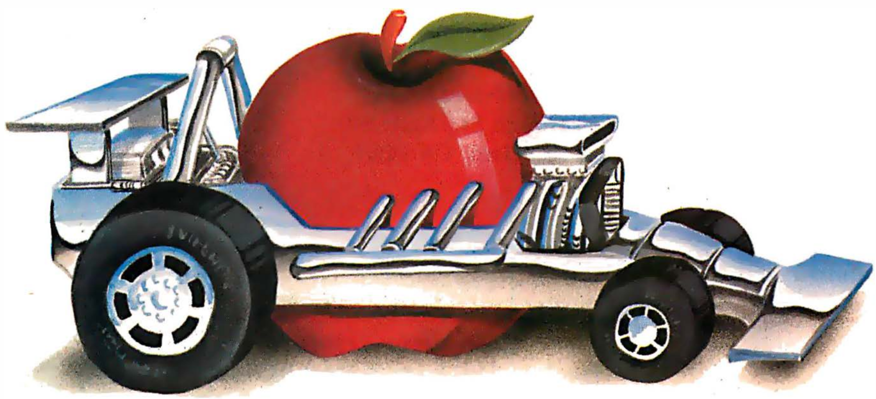
Marvin Konopik
American Embassy
APO San Francisco, CA 96356

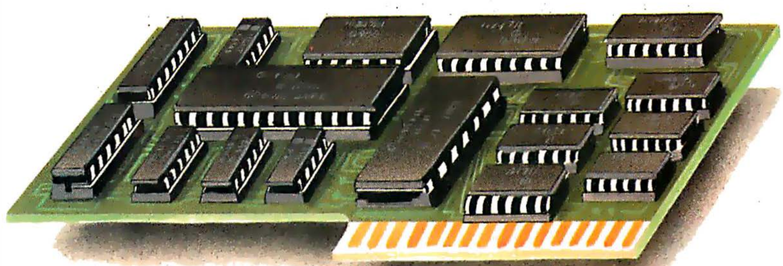
Address Correction

The International Association of Computer Crime Investigators was mentioned several times in "Computer Crime: A

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Growing Threat" by Collen Gillard and Jim Smith (October 1983, page 398). We are a newly formed nonprofit public-benefit corporation created to professionalize and educate the data-processing, legal, and criminal-justice communities in computer-crime investigation. Our address was incorrectly listed as Burlingame, California. Our correct address for anyone who may be interested in more information is:

International Association
of Computer Crime Investigators
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San Francisco, CA 94109

As we indicated in the article, we also collect data on computer crime cases. This type of information is made available to our members on a periodic basis. We are an international organization with members covering several continents.

Bruce Goldstein
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Computer Crime Giving Hackers a Bad Name

As a hacker, I feel that the term "hacker" has received a new, derogatory connotation implying illegal computer use. I have been using computers for about 10 years, and the term has always meant "one who is a computer hobbyist." I feel that those who access a computer without permission using false passwords should be accused of forgery!

Granted, it's sometimes easy to hit (access) a system, but saying "There's no security; it's so easy" does not erase the fact that access was granted under false pretense. It's also easy to write someone else's signature on checks or documents, but that doesn't make it right. Because computers cannot read a person's signature, the password became the computer equivalent of a signature. Those who use a false or forged password should be treated as forgers.

The recent article "Computer Crime: A Growing Threat" (October 1983, page 398) that referenced this problem was far from complete and a little misleading. The Los Alamos computer that was accessed was specially designed for easy public access. (See *Electronics*, September 8, 1983, page 52.) And the last half of the article reads like an ad for the Secure Access Unit (SAU) hardware. The author failed to acknowledge that the same protection can be obtained with a simple software addition. In fact, all the SAU is is a computer and autodial modem. Why use two computers when you already have one that will easily handle the job?

As a hacker, I feel that the articles about computer theft are giving us a bad name. How about some positive articles on remote bulletin boards, remote systems, and public-domain software?

Mike Woodward
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Suisun, CA 94585

Kudos to Steve

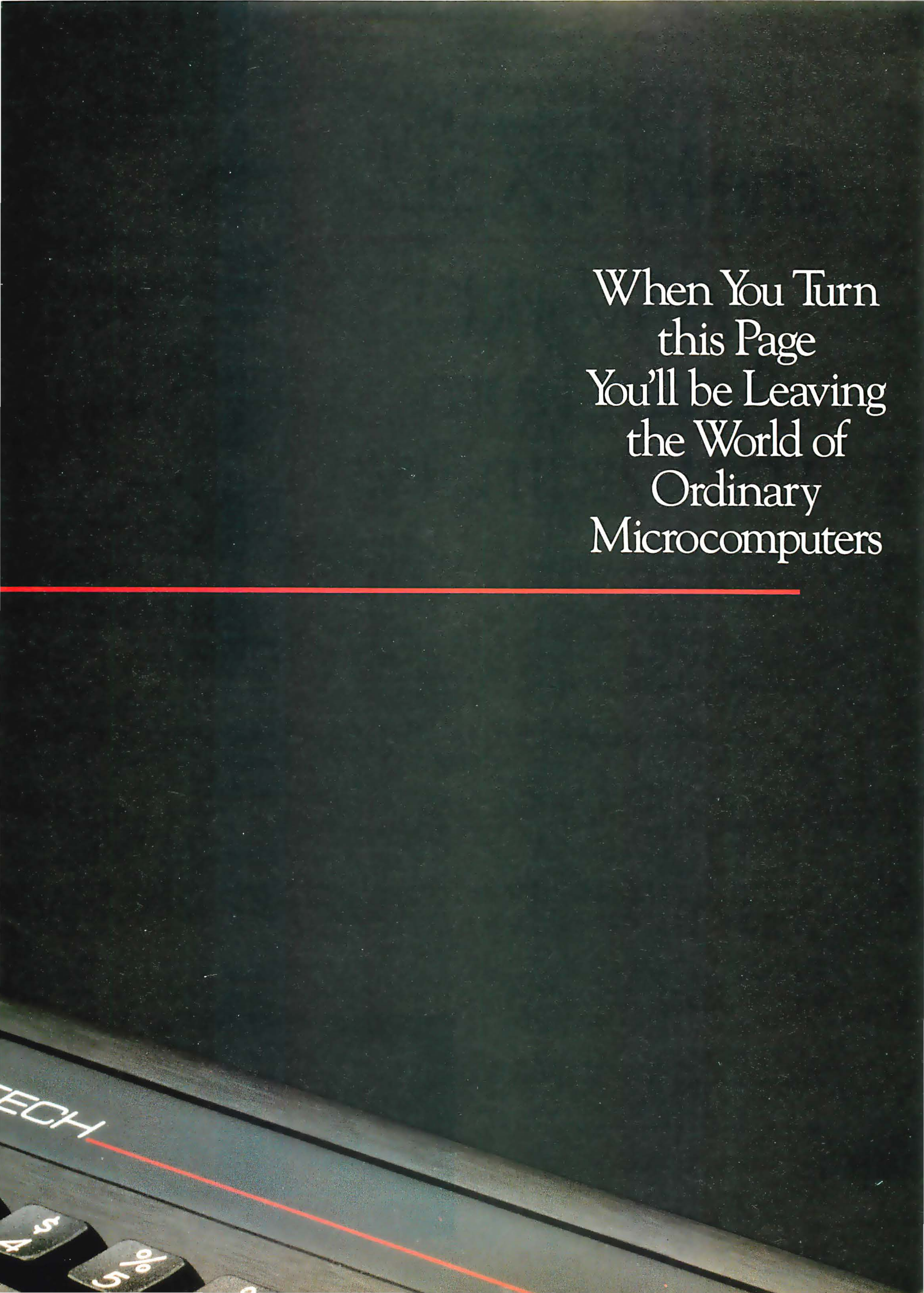
Again, Steve Ciarcia has another excellent construction article, "Build the H-COM Handicapped Communicator," (November 1983, page 36). Although I have no use for the communicator described, the article provided a wealth of information on single-chip microcomputer solutions to seemingly complex problems. I look forward to more projects like this, especially the well-documented, fun-to-read assembly-language listing. Keep up the good work.

Chris Brown
FEI/AMSF-EUR
APO New York, NY 09086

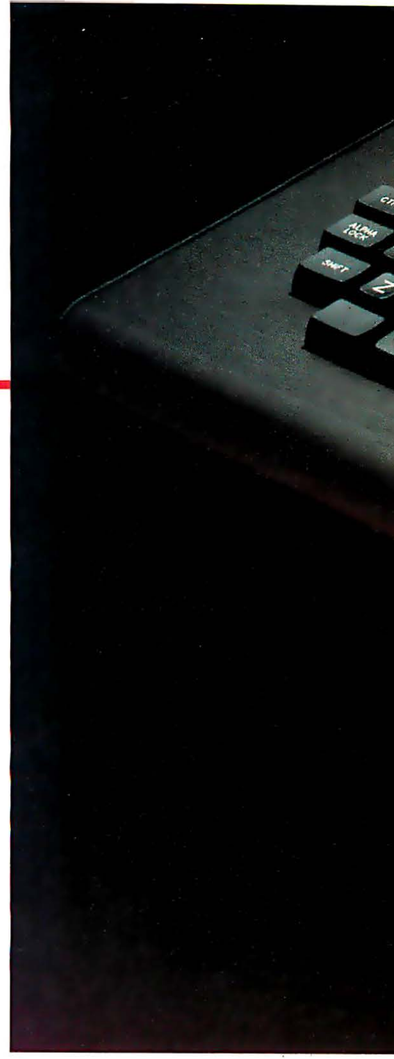
A Clarification

I would like to comment on Mark Haas's review of the TI Professional in the December 1983 issue. On page 320, while comparing the TI and the IBM PC, he claims that the TI "also has a PSET STEP variation" which, in the context, implies that the IBM PC does not. In fact, IBM PC graphics coordinates can be used in the STEP format. There is a description of this in Chapter 3 of the IBM PC *BASIC* manual, beginning on page 38.

Daniel Bernstein
5 Brewster Ln.
Bellport, NY 11713■


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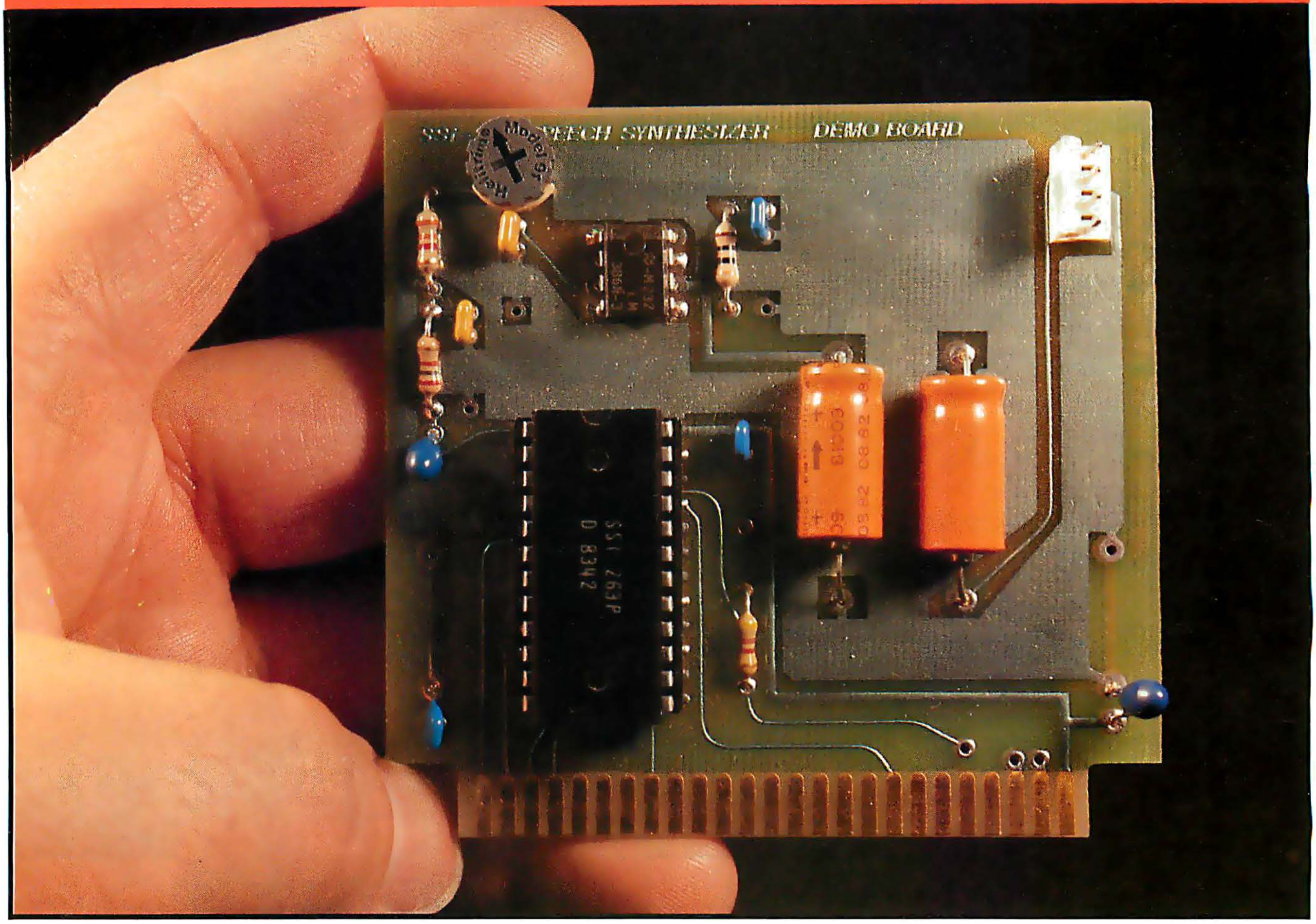
A world in which all microcomputers will suddenly seem very different.

Suddenly very ordinary.

For more information about the MTX512, or to find out the location of the MTX dealer nearest you, contact Memotech Corporation, 99 Cabot Street, Needham, MA 02194; or phone (617) 449-6614

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*DMX80 correspondence quality printer suggested retail price $395.
**Suggested retail price.



Build a Third-Generation Phonetic Speech Synthesizer

by Steve Ciarcia

The idea for this month's project may seem familiar to many of you, and with good reason: I've done projects on building speech synthesizers five times before. Why? The integrated-circuit technology for doing it keeps getting better and better, and I like nothing more than experimenting with new chips.

The Shadow of the Past

The most successful of the past speech-synthesis projects were the Sweet Talker, presented in September 1981 (see reference 3), and the Microvox, presented in August and September 1982 (see reference 4). Many of you have built and used these as peripheral devices on your personal computers.

The original Sweet Talker was a simple, parallel-port-driven phoneme-based synthesizer. To make it talk, you just sent 6-bit phoneme codes to it. It's still useful; I've used it for broadcasting weather reports, among other things (see reference 1). The Microvox was an enhancement of the same basic design. Both these devices were built around the Votrax SC-01A chip, a member of the second generation of commercial speech-synthesis products. (The first generation consisted of hybrid modules containing many discrete components.)

Latest Technology

I suppose I would continue to tinker with improving the sound quality from this foundation if I had not been beaten to the punch by the appearance of an enhanced speech-synthesis chip. This month we'll look at the latest development in phonetic speech synthesis: the SSI263 integrated circuit from Silicon Systems Inc.

Speech-synthesis chips of the new third generation, such as the SSI263, produce much more intelligible

The latest development in phonetic speech synthesis is the Silicon Systems SSI263 chip

speech than did older devices, such as the SC-01A. The new chips achieve this through more flexible intonation, inflection, and filtration. With the SSI263, it is possible to vary these three effects on the fly as well as load new speech phonemes dynamically. When synthesizing in this way from sufficiently detailed data (at about 400 bits per second), the SSI263 generates the most human-sounding synthesized voice I've heard to date. (Systems that reproduce a digitized human voice can still sound better, however.) In its minimal operating mode, which requires data at about 50 to 70 bits per second, the quality of sound is comparable to that produced by the Votrax SC-01A.

Sweet Talker II

Seeing that the SSI263 could be easily interfaced to many different microprocessor-based systems, I decided to use an Apple II Plus as its host because the Apple's allocation of a separate address space for each expansion slot would eliminate address decoding on the speech card. The board, which contains only two chips, can be adapted for use with many other computers if you don't mind a little extra wiring. Out of sentiment for my earlier project, I decided to call the new package the "Sweet Talker II." It's shown in photo 1.

Programming the Sweet Talker II can be simple, if you'll settle for a monotonic, uninflected voice, or complicated, if you need the highest quality speech. Unlike its predecessor, the SC-01A, which used only a 6-bit phoneme input, the SSI263 contains five registers (totalling 40 bits) that influence the emitted sound. With the constant updating of all the registers (at a higher data rate and controlled by a more complex program), the SSI263 can even sing with vibrato.

Because the SSI263 is just out on the market, very little has been published on it. After a review of the basic techniques of computer speech, we'll go through some specific information about the device. Following that, we'll look at the simplicity of interfacing the SSI263 to a personal computer and discuss the software needed to support it.

Review of Computer Speech

There are three major techniques presently employed to allow computers to speak: formant synthesis, linear-predictive coding (LPC), and waveform digitization. The most noticeable difference between these three methods is the amount of data required to construct a word.

In *formant synthesis*, an electronic model of the human vocal tract is constructed. Driven with signals from frequency and noise generators, the model mimics the natural resonances of the vocal tract. The output spectrum contains bands of resonant frequencies called formants.

The most common variant of the formant technique is called *phoneme synthesis*, in which the spectral parameters are derived from basic word sounds—the phonemes. In such a circuit, each phoneme is assigned a digital code; the synthesizer circuit utters phoneme sounds corresponding to the codes it receives. Therefore, speech is produced simply by stringing the phoneme codes together.

The original electronic voices of this type were intelligible but had a slightly mechanical quality. The latest phoneme synthesizers, on the other hand, combine control of pitch, rate, amplitude, and filtration to achieve quite lifelike speech. Continuous speech using phoneme synthesis can generally be obtained with data at a rate of less than 100 bps (bits per second), using no extra control attributes. Even with all the embellishments, it never requires a data rate of more than 400 bps.

Linear-predictive coding (LPC) is similar to formant synthesis in that both techniques are based on the frequencies found in speech and use similar hardware to model the vocal tract. Instead of encoding phonemes, however, LPC uses stored filter coefficients, amplifier-gain settings, and excitation frequencies; the name of the method is derived from the programmed activities of the multistage lattice filters that produce the desired formants. Continuous speech can generally be achieved with data rates of 1200 to 2400 bps. LPC has been used in products from Texas Instruments (the Speak & Spell and the now-discontinued TI 99/4 Text-to-Speech Translator) and General Instrument (the VSM2032 Voice Synthesis Module).

The third technique of computerized speech is *waveform digitization*, which reproduces a voice waveform from its stored amplitude characteristics. The simplest form is uncompressed digital data recording by pulse-code modulation (PCM). A more complex method involving data compression is called adaptive differential pulse-code modulation (ADPCM).

In digital recording by PCM, the analog waveform from a real human voice is sampled at a frequency twice that of the highest frequency to be preserved from the voice; the samples are sent through an analog-to-digital (A/D) converter and stored. The digital signal is played back through a digital-to-analog (D/A) converter and a low-pass filter. Since it's essentially a recorded voice, the reproduced speech retains the original inflections and accents. Unfortunately, waveform digitization requires very high data rates, so the vocabulary is usually limited by the amount of data that can be stored.

For more detail on speech digitization, you can refer to some of my previous articles in BYTE. In June 1978 I published a simple project for digitizing and reproducing speech from uncompressed data; you might call it "brute-force digitization" (see reference 5). The second project,

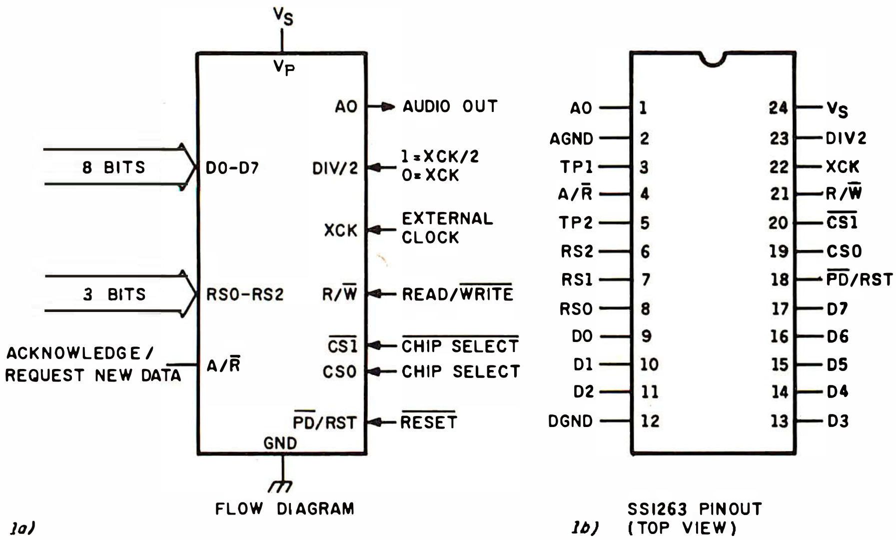


Figure 1: *Pinouts of the Silicon Systems SSI263 speech-synthesizer integrated circuit.*

1. appropriate control inputs (R/W, CS0, and CS1) for address mapping with several buses
2. provision for resetting at power-down
3. five 8-bit internal registers
4. 256 phoneme equivalents (64 different phonemes each with four different duration settings)
5. four modes of handshaking
6. 4096 pitch variations (32 absolute levels with eight different speeds of inflection)
7. 16 speed settings
8. 16 amplitude levels
9. eight rates of articulation
10. 255 settings of the vocal-tract filter frequency response

Table 1: *Operational characteristics of the SSI263.*

Support for the SSI263

As with many Circuit Cellar projects, the Sweet Talker II is available with the text-to-speech software from a source listed at the end of the article. In true Circuit Cellar tradition, however, many of you will hard-wire the unit as I've detailed. Unfortunately, since the program is owned by Silicon Systems Inc., royalties are involved and it cannot be published. In an effort to reward rather than diminish your handiwork, I will pay the royalty and provide the Apple II software to anyone sending me a photograph of his or her custom-assembled Sweet Talker II. This offer extends to noncommercial applications and individual experimenters until June 1, 1984.

In the long term, the SSI263 will be supported by Sweet Micro Systems, the company that makes the Mockingboard music-synthesis system for the Apple II. Sweet Micro Systems' latest version of the Mockingboard can use two optional SSI263s to provide synthesized voices that can sing along in stereo with the synthesized two-channel music; the chips are plugged right into sockets on the circuit board. Photo 3 on page 40 shows the new Mockingboard, containing one SSI263, plugged into an Apple II Plus.

I've made sure that the Sweet Talker II will be software-compatible with the voice software intended for the Mockingboard, and it should be compatible with other SSI263-based products for the Apple II as well.

published in June 1981, was for reproducing digitized speech from compressed data (reference 2), and the third article, appearing in June 1983, was a project that used ADPCM (see reference 6.)

SSI263 Integrated Circuit

The Silicon Systems SSI263 is a self-contained phoneme-based speech synthesizer. It consists of a single 24-pin CMOS (complementary metal-oxide semiconductor) integrated circuit that runs from a 5-V (volt) power source. It provides an analog output for music, sound effects, and continuous speech of unlimited vocabulary at low data rates. The SSI263 is easy to interface with any microprocessor; its principal characteristics are listed in table 1. Figure 1 contains a pinout diagram; a description of each pin's function is shown in table 2. The SSI263 can use a 3.59-MHz color-burst crystal divided by 2 or 4 as a timebase, or it can run off an external 1- or 2-MHz clock signal.

The SSI263 contains five 8-bit internal registers, which allow 256 phoneme-equivalents; 4096 pitch variations; and control of amplitude, rate of articulation, and vocal-tract filter frequency response (useful for sound effects). The individual registers are described in the text box on page 38.

A Simple Circuit

Connecting the SSI263 to any microcomputer system is not hard, but with the Apple II family of computers (II, II Plus, and IIe) the connection is simplicity itself (due largely to the address decoding provided on the Apple's motherboard). As you can see in figure 2 on page 32, the entire Sweet Talker II circuitry consists of only two integrated circuits and a few passive components.

In figure 2, IC1 is the SSI263, which can be directly connected to the Apple's data and address buses, operating on interrupts generated on the IRQ (normal interrupt request) line. The chip is selected when the A6 address line and the R/W and I/O-select status lines are active. Address lines A0, A1, and A2 select the proper register for data to be entered through the eight data-bus lines D0 through D7. The three low-order address lines are individually asserted to trigger one of three mutually exclusive register-select inputs on the voice-synthesis chip: RS0, RS1, or RS2.

When plugged into expansion slot 4 of any Apple II-series computer, the registers are addressed at hexadecimal C400 through C404 (decimal addresses 50240 through 50244).

The remaining components on the speech-synthesizer board constitute the amplifier and filter sections.

Capacitors C4 and C5 and resistors R2 and R3 form a simple low-pass filter. The audio signal is then amplified by an LM386 1-watt operational amplifier (IC2) to directly drive an 8-ohm speaker. Potentiometer R4 controls the volume on the external speaker (connected to the header provided). In addition to the +5-V supply needed by the SSI263, the board requires a +12-V supply to power the op amp.

Pin	Function
1	AO (Audio)—analog output, DC-biased at $V_{DD}/2$. Requires an external audio amplifier to drive speaker.
2	AG (Analog Ground)—must be connected to a good ground potential to eliminate noise in the output signal.
3	TP1 (Test Point 1)
4	A/$\overline{R}$ (Acknowledge/Request—Not)—digital open-collector output. When forced low it requests new data. It can respond on a frame or phoneme boundary condition or be deactivated (see DR0, DR1—page 38—and $\overline{PD}$/RST). This signal can also be read on D7 in an inverted state.
5	TP2 (Test Point 2)—normally not used.
6	RS2 (Register Select 2)—used in conjunction with RS1 and RS0, these three register select lines are used to select and write to one of five internal registers.
7	RS1 (Register Select 1)
8	RS0 (Register Select 0)
9	D0—first of data lines, listed in order of increasing significance
10	D1
11	D2
12	V_{SS} (ground)
13	D3
14	D4
15	D5
16	D6
17	D7—most significant bit of 8-bit data bus. D7 is bidirectional. When read, high is an active request for new data and low is an acknowledgment that data has been received (A/$\overline{R}$).
18	$\overline{PD}$/RST (Power Down—Not/Reset)—this input is active in the low state. When active, it powers down the SSI263 and silences the audio output and retains its DC bias without disturbing the internal registers. It also puts the SSI263 in a disabled-A/$\overline{R}$ mode.
19	CS0 (Chip Select 0)—control input that selects the SSI263 on a microprocessor control/mapping bus, active high.
20	$\overline{CS1}$ (Chip Select 1—Not)—active-low state.
21	R/$\overline{W}$ (Read/Write—Not)—control input, write is an active-low state (writes into D0 through D7), read is an active-high state (reads D7 only).
22	XCLK (External Clock Input)—input for externally supplied clock. Normal frequency input is in two ranges: 2.0 MHz/1.79 MHz or 1.0 MHz/895 kHz dependent upon level of DIV2 input.
23	DIV2 (External Clock Divide-by-2 Input)—when this input is high, XCLK = 2 or 1.79 MHz. When this input is low, XCLK = 1 or 0.895 MHz.
24	V_{DD} (Positive Voltage Supply)—V_{DD} operating range is +4.5 V DC to 6.6 V DC.

Table 2: *Pin functions of the SSI263.*

Speaking in Phonemes

All the words in the English language can be written using only 26 alphabetic characters, but the language contains far more than 26 sounds—most letters of the alphabet (or combinations) can represent more than one sound. As a practical matter, English can be considered to contain 50 or so distinct sounds, called *phonemes*. These are listed in table 3 on page 33.

It's not as hard to use the phoneme list as it first appears. For example, the phonemes in the word "disk" are written as follows:

D I S K

Simple enough. From the table, the corresponding digital codes (in hexadecimal) are

25 07 30 29

These are the values fed into the speech synthesizer.

Few words are quite that easy, though. For instance, the five distinct phonemes in "hello" are

HF EH L O W

These are translated into the hexadecimal codes

2C 0A 20 11 23

It isn't necessary for you to become a linguist to use a phonetic speech synthesizer because many lists of words and their phoneme equivalents are available (see reference 3).

Programming for Phoneme Synthesis

The speech-synthesizer board speaks a word when it receives, in sequence, the codes for the constituent phonemes. The programming for this can be simple: POKE statements in BASIC suffice. If the synthesizer were plugged into slot 4 of an Apple II, the program of listing 1 would cause it to say "hello" in a monotonic voice. Observe that the program loads the stop phoneme (hexadecimal 0) after the end of the word; this makes the synthesizer stop sounding the last phoneme.

You'll also note that the first six executable statements in listing 1 load constant values into the registers in the speech-synthesis chip; the five attribute registers in the SSI263 must be properly initialized; once they have been, a program using this method can cause the chip to emit the sounds of essentially any word or series of words. But an interpreted BASIC program is not fast enough to operate in an interrupt mode or dynamically change the attribute registers with each phoneme.

So a program in BASIC can only scratch the surface of the SSI263's

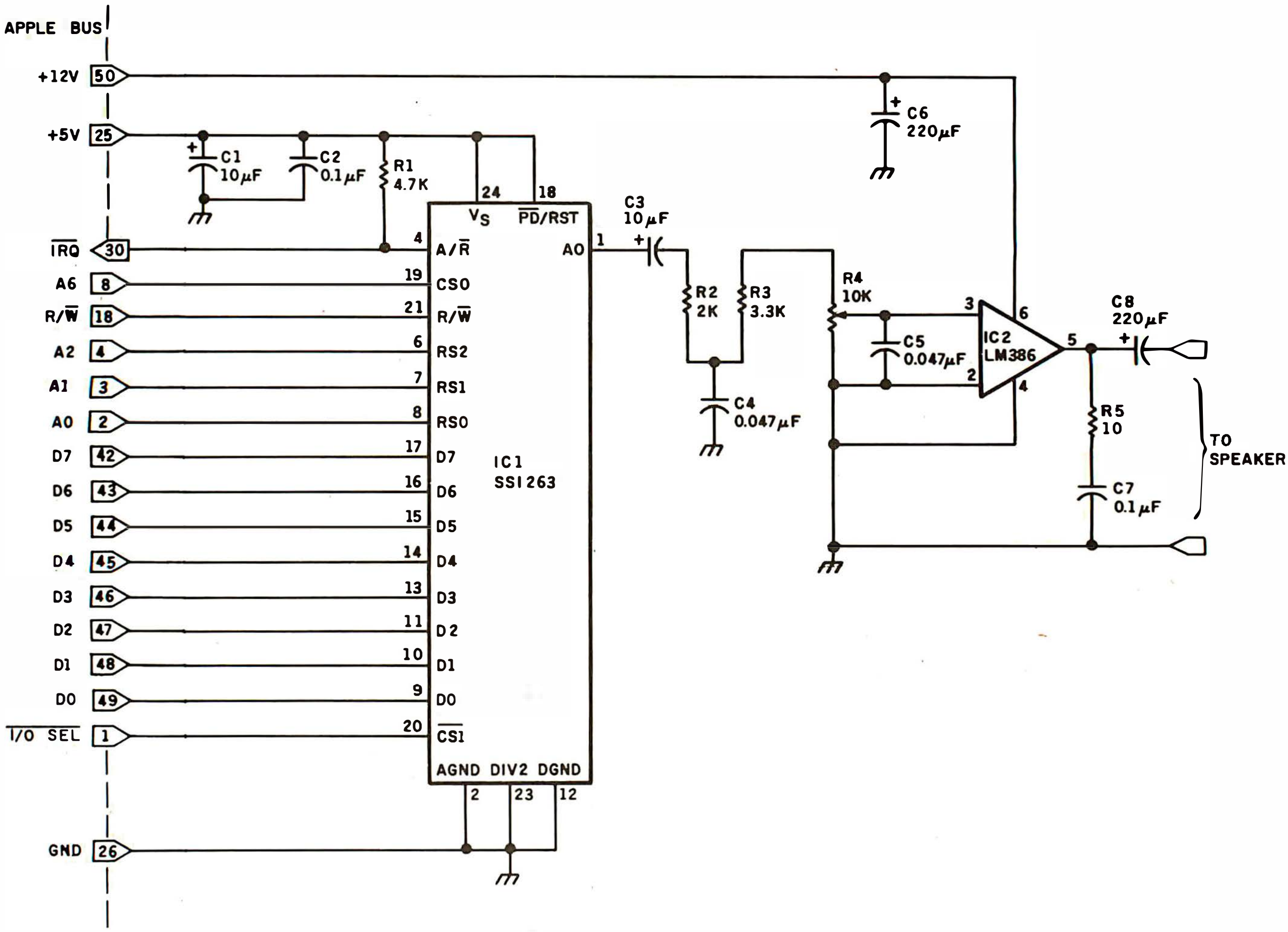


Figure 2: *Schematic diagram of the Sweet Talker II circuitry.*

Listing 1: *This BASIC program causes the Sweet Talker II to pronounce the word "hello" by sending it the minimal set of phoneme codes.*

```
1Ø REM SET UP SSI263 FOR TRANSITIONED INFLECTION
2Ø POKE 5Ø243,255 :REM CONTROL BIT EQUALS 1
3Ø POKE 5Ø24Ø,192 :REM SET PHONEME DURATION
4Ø POKE 5Ø243,116 :REM CONTROL BIT EQUALS Ø AND SET AMPLITUDE
5Ø POKE 5Ø244,231 :REM SET FILTER FREQUENCY TO NORMAL
6Ø POKE 5Ø242,168 :REM SET SPEECH RATE TO NORMAL
7Ø POKE 5Ø241,127 :REM SET INFLECTION LEVEL
1ØØ HOME
11Ø PRINT "HELLO"
12Ø DATA 44,1Ø,32,17,35,Ø :REM PHONEMES FOR WORD HELLO
13Ø FOR X=1 TO 6
14Ø READ A
15Ø POKE 5Ø24Ø,A :REM LOAD PHONEME INTO INPUT REGISTER
16Ø FOR T=Ø TO 5Ø :NEXT T :REM DELAY TIL NEXT PHONEME TIME
17Ø NEXT X
18Ø END
```

capabilities. To really appreciate what it can do, you have to exercise the chip with an assembly-language program that adds inflection and intonation. The program in listing 2 on pages 34 and 35 also causes the system to say "hello" but with superior results. For speech applications requiring the most reliable intelligibility, an assembly-language word-list-to-phoneme output program is required.

But many applications require an essentially unlimited vocabulary, for instance, if you wanted your computer to read aloud the stories on the Associated Press newswire. (By the way, that's an acid test for intelligibility of synthesized speech.) In such cases, you'll need a program that can perform its own translation from normal spelling to phoneme codes using a text-to-speech algorithm.

Text-to-Speech Algorithm

A text-to-speech algorithm is a program that takes words spelled out in letters encoded in ASCII (American National Standard Code for Information Interchange) and analyzes them. It determines which characters are silent and which should produce sounds, and what kind of sounds, by following a set of general pronunciation rules. Most research in such synthesis by rule has been on English, but text-to-speech algorithms have been written for other languages as well.

The amount of program code

(3a)

Table 3: *Elementary speech sounds, or phonemes, that occur in English and a few other languages. Consonants are shown in 3a; vowels are listed in 3b. The four code columns for each phoneme represent spoken sounds of different length. You can choose the length that provides the best intelligibility or most pleasing sound. From left to right, the lengths decrease by about 25 percent in each column from the previous one. The code in column 1 can usually be used as the default value.*

Phoneme	Code 1	2	3	4	Examples
B	24	64	A4	E4	bat, tab
D	25	65	A5	E5	dub, bud
F	34	74	B4	F4	fat, ruff, photo, laugh
HV	2A	6A	AA	EA	eh
HVC	2B	6B	AB	EB	(post-B aspiration as in "tab")
HF	2C	6C	AC	EC	hat, home
HFC	2D	6D	AD	ED	(post-P aspiration as in "pad")
HN	2E	6E	AE	EE	ba-ba black sheep (voiceless glottal stop)
J	31	71	B1	F1	job, rage
K	29	69	A9	E9	kit, tick
KV	26	66	A6	E6	big, gag
L	20	60	A0	E0	lab, ball
L1	21	61	A1	E1	plan, club, slam
LB	3F	7F	BF	FF	il (French)
LF	22	62	A2	E2	bottle
M	37	77	B7	F7	mad, dam
N	38	78	B8	F8	not, ton
NG	39	79	B9	F9	ring, rang, drink, drank
P	27	67	A7	E7	pat, tap
R	1D	5D	9D	DD	rat
R1	1E	5E	9E	DE	(French)
R2	1F	5F	9F	DF	(German)
S	30	70	B0	F0	sat, lass
SCH	32	72	B2	F2	shop, push
T	28	68	A8	E8	tap, pat, baked
THV	35	75	B5	F5	bathe, the
TH	36	76	B6	F6	bath, theory
V	33	73	B3	F3	vow, pave
W	23	63	A3	E3	why, quake
Y	03	43	83	C3	(French)
Y	04	44	84	C4	you
Z	2F	64	A4	E4	zap, maze
(space)	00	40	80	C0	(pause)

(3b)

Phoneme	Codes 1	2	3	4	Examples	Comments
A	08	48	88	C8	day	
A1	09	49	89	C9	care	
AE	0C	4C	8C	CC	dad, plaid	
AE1	0D	4D	8D	CD	ask	
AH	0E	4E	8E	CE	top, father	
AH1	0F	4F	8F	CF	about	
AW	10	50	90	D0	saw, caught	
E	01	41	81	C1	beet, be	
E1	02	42	82	C2	advent	
EH	0A	4A	8A	CA	leg, said	
EH1	0B	4B	8B	CB	silent	
ER	1C	5C	9C	DC	third, urn, heard	
I	07	47	87	C7	sit, bid	
O	11	51	91	D1	boat	
OO	13	53	93	D3	put, pull, look	
OU	12	52	92	D2	orb	
U	16	56	96	D6	boot, you	
U1	17	57	97	D7	poor	
UH	18	58	98	D8	cup	
UH1	19	59	99	D9	nation, circus	
UH2	1A	5A	9A	DA	nation, circus	
UH3	1B	5B	9B	DB	nation, circus	
Foreign Sounds						
AY	05	45	95	C5	français	French
A	3A	7A	BA	FA	être	French, or umlauted a (ä) in German
E2	3E	7E	BE	FE	schön	German
IE	06	46	86	C6	il	French
IU	14	54	94	D4	peut	French
IU1	15	55	95	D5	Goethe	German
OH	3B	7B	BB	FB	menu, tu	French
U	3C	7C	BC	FC	Fühlen	German
UH	3D	7D	BD	FD	menu, tu	French

needed to implement a text-to-speech algorithm varies, with longer programs usually performing better. Typical microprocessor routines are in the 4K- to 8K-byte range, but some of the more sophisticated programs take up to 80K bytes. The main difference between the most common algorithms is the number of pronunciation exceptions and the length of word tables. An 80K-byte routine, for example, is often 90 percent look-up tables of words that are pronounced in unpredictable ways.

The Sweet Talker II speech synthesizer outlined in this article can be made to speak by direct input of individually selected phonemes, as demonstrated above, or through use of a text-to-speech algorithm. While two of my previous Circuit Cellar speech-synthesis projects, the Sweet Talker I and the Microvox, had some form of text-to-speech capability, they were built around the Votrax SC-01A; the software is not compatible with the SSI263 in the Sweet Talker II.

At first, I thought I would have to

Listing 2: *An assembly-language program for the 6502 microprocessor that causes the synthesizer to say "hello" with better inflection and intonation by sending more data than the BASIC program.*

```
                 * SSI-263 COMPOSITE DATA DRIVER
                 *
                 *
                           ORG   $8000
                 *
                 *
                 OUTPTR    EQU   $FB          ;POINTER TO START OF DATA
                 ENDPTR    EQU   $FD          ;POINTER TO END OF DATA
                 BUSY      EQU   $FF          ;BUSY FLAG
                 IRQL      EQU   $03FE        ;IRQ VECTOR, LOW BYTE
                 IRQH      EQU   $03FF        ;IRQ VECTOR, HIGH BYTE
                 BASE      EQU   $C440        ;REGISTER 0 OF SSI-263
                 DURPHON   EQU   BASE
                 INFLECT   EQU   BASE+$01     ;REGISTER 1 OF SSI-263
                 RATEINF   EQU   BASE+$02     ;REGISTER 2 OF SSI-263
                 CTTRAMP   EQU   BASE+$03     ;REGISTER 3 OF SSI-263
                 FILFREQ   EQU   BASE+$04     ;REGISTER 4 OF SSI-263
                 *
                 *
                 * SET-UP ROUTINE *
                 *
                 *
8000: 78                   SEI                ;DISABLE INTERRUPTS
8001: A9 2E                LDA   #<INTERR     ;INT SERVICE ROUTINE, LOW ADDRESS
8003: 8D FE 03             STA   IRQL
8006: A9 80                LDA   #>INTERR     ;INT SERVICE ROUTINE, HIGH ADDRESS
8008: 8D FF 03             STA   IRQH
                 *
800B: A9 80                LDA   #>TABLE      ;DATA TABLE, HIGH ADDRESS
800D: 85 FC                STA   OUTPTR+1
800F: 85 FE                STA   ENDPTR+1
8011: A9 69                LDA   #<TABLE      ;DATA TABLE, LOW ADDRESS
8013: 85 FB                STA   OUTPTR
8015: A9 9B                LDA   #<TABLE+$32
8017: 85 FD                STA   ENDPTR
                 *
                 *
8019: A9 FF                LDA   #$FF         ;SET BUSY FLAG
801B: 85 FF                STA   BUSY
801D: A9 80                LDA   #$80         ;SET SSI-263 TO
801F: 8D 43 C4             STA   CTTRAMP      ;TRANSITIONED INFLECTION MODE
8022: A9 C0                LDA   #$C0
8024: 8D 40 C4             STA   DURPHON
8027: A9 70                LDA   #$70
8029: 8D 43 C4             STA   CTTRAMP
802C: 58                   CLI                ;CLEAR INTERRUPT MASK
802D: 60                   RTS                ;RETURN TO CALLER
                 *
                 *
                 * INTERRUPT SERVICE ROUTINE *
                 *
                 *
802E: 8A         INTERR    TXA                ;SAVE X REGISTER
802F: 48                   PHA
8030: 98                   TYA                ;SAVE Y REGISTER
8031: 48                   PHA
8032: A0 00                LDY   #$00         ;INIT Y REGISTER
8034: A2 04                LDX   #$04         ;INIT X REGISTER
8036: A5 FB                LDA   OUTPTR       ;CHECK FOR END OF DATA
8038: C5 FD                CMP   ENDPTR
803A: D0 1B                BNE   CONT         ;NO, SO CONTINUE
803C: A5 FC                LDA   OUTPTR+1
```

Listing 2 continued on page 35

Listing 2 continued:

```
803E: C5 FE              CMP   ENDPTR+1
8040: D0 15              BNE   CONT         ;NO, SO CONTINUE
8042: A9 00              LDA   #$00         ;END, SO TURN OFF SSI-263
8044: 8D 40 C4           STA   DURPHON
8047: A9 70              LDA   #$70
8049: 8D 43 C4           STA   CTTRAMP
804C: A9 00              LDA   #$00         ;RESTORE BUSY FLAG
804E: 85 FF              STA   BUSY
8050: 68          RET    PLA                ;RESTORE Y REGISTER
8051: A8                 TAY
8052: 68                 PLA                ;RESTORE X REGISTER
8053: AA                 TAX
8054: A5 45              LDA   $45          ;RESTORE ACCUMULATOR
8056: 40                 RTI                ;RETURN FROM INTERRUPT
                  *
                  *
8057: B1 FB       CONT   LDA   (OUTPTR),Y   ;GET DATA
8059: 9D 40 C4           STA   BASE,X       ;AND PASS IT TO SSI-263
805C: E6 FB              INC   OUTPTR       ;INCREMENT POINTER
805E: D0 02              BNE   CONT1
8060: E6 FC              INC   OUTPTR+1
                  *
8062: CA          CONT1  DEX                ;NEXT REGISTER
8063: E0 FF              CPX   #$FF         ;LAST REGISTER?
8065: D0 F0              BNE   CONT         ;NO, SO CONTINUE
8067: F0 E7              BEQ   RET          ;EXIT INTERRUPT
                  *
                  *
                  *
                  *
8069: E7 3B A8
806C: 7A AC       TABLE  HEX   E73BA87AAC
806E: E8 4D A8
8071: 7B CA              HEX   E84DA87BCA
8073: E8 5D A8
8076: 74 CA              HEX   E85DA874CA
8078: E7 6C A8
807B: 64 E0              HEX   E76CA864E0
807D: E7 7B A8
8080: 53 A0              HEX   E77BA853A0
8082: E7 7A A8
8085: 5A 11              HEX   E77AA85A11
8087: E7 79 A8
808A: 61 63              HEX   E779A86163
808C: E7 70 A8
808F: 60 00              HEX   E770A86000
8091: E7 70 A8
8094: 58 00              HEX   E770A85800
8096: E7 70 A8
8099: 50 00              HEX   E770A85000
                  *
                  *
```

find a new text-to-speech program. Fortunately, Silicon Systems had foreseen the demand for a text-to-speech routine for the SSI263 and arranged for the necessary software to be available under license.

Customizing Software

The Sweet Talker II's text-to-speech routine was produced by Sweet Micro Systems of Cranston, Rhode Island. It was derived from an algorithm originally developed at the Naval Research Laboratory and uses a similar rule-definition format. But it's much more versatile, and it nicely uses the talents of the SSI263. (At this writing, the software has been implemented only for the Apple II computer family.)

One problem of text-to-speech translation is of personal interest to me. There isn't an algorithm written that can digest and properly pronounce "Ciarcia" (it should sound like "see-ARE-see-uh") unless there is a specific rule for that character string that outputs a predetermined set of phonemes when the string is detected.

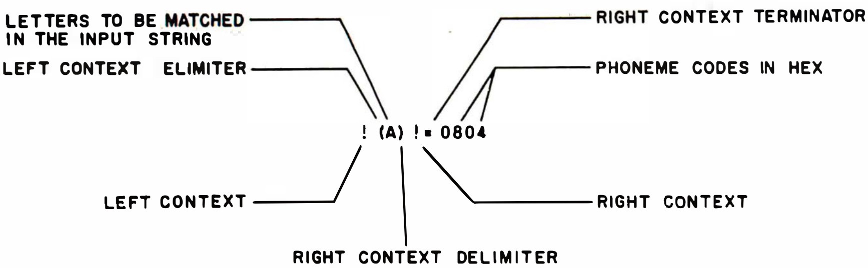


Figure 3: *Format of the rules in the text-to-speech algorithm.*

Symbol	Function
!	represents any nonalphabetic character in the input string
#	represents one or more vowels
:	represents zero or more consonants
+	represents a front vowel (E, I, Y)
$	represents one consonant
.	represents a voiced consonant (B, D, G, J, L, M, N, R, V, W, Z)

Table 4: *Context symbols used in the rules of the text-to-speech algorithm.*

Most text-to-speech routines don't let you modify the rule tables or expand the number of exceptions. The Sweet Micro Systems program employs a rule-based method that encompasses whole-word, morpheme, and letter rules in character-specific subtables. Furthermore, this new program also comes with a utility routine for changing, editing, or redefining those rules. The utility can even adjust the size of the main routine depending on whether rules or characters in the rules have been inserted or deleted. This flexibility in design allows you to totally redefine the rule table for foreign languages and dialects, to prepare for certain proper names, or simply to improve pronunciation of a specific frequent word.

The original Naval Research Laboratory algorithm did not include any facility for varying intonation and stress, but the software for the SSI263 uses a simple yet effective system of stress markers to allow intonation and stress to be specified. (In addition, a more extensive utility program is available that provides total control over parametric changes on an individual phoneme basis. This utility routine allows you to create high-quality words or phrases that can be easily used in any application, without the need for the text-to-speech algorithm and rule table to be resident in memory at the time of execution.)

How the Algorithm Works

Before I describe the rule-based text-to-speech algorithm, an explanation of the rule format is in order. Figure 3 shows that each rule consists of several different components. The letter or letters contained within the parenthetic delimiters are the characters to be matched in the input string. The symbols to the left of the delimiters define the left context (what comes before the characters to be matched), and the the symbols to the right define the right context. The context symbols' meanings are listed in table 4. The equals symbol ("=") denotes the end of the rule definition, and the numbers to the right are the phoneme codes in hexadecimal. Most rules have a left or right context for the matched characters, but some situations do not require either.

The routine begins by converting the entire input string to uppercase characters to maintain uniformity in conversion. During this period, all characters in the input string are categorized and marked according to the symbol groupings described in table 4, and corresponding rule symbols are stored for later use. Also, stress markers are found and marked for use in the determination of intonation and stress characteristics.

The first input character is then compared to the first applicable rule in the subtable for that character. Since all rules in a single subtable begin with the same character, the algorithm attempts to match the left context first, then if the match succeeds, it attempts to match the second and following characters, if any, remaining in the parenthetic string. If that match succeeds, the algorithm attempts to match the right context. Should any match attempt fail, the algorithm proceeds to the next rule in the subtable and attempts to match that rule.

The last rule in every rule subtable for a given letter contains a parenthetic string of just that letter with no left or right context, thus guaranteeing a match for any letter in the input string. Once a match has been achieved, the algorithm then places the phoneme codes designated in the rule (to the right of the equals sign) into a phoneme buffer.

The rule table also allows the definition of punctuation marks and numbers. This allows a description of those characters to be pronounced. Some rules, for silent letters, are defined with no phoneme codes. The algorithm simply places nothing in the phoneme buffer and proceeds to the next character in the input string.

When the routine attempts a match on either the left or right context, it may encounter special symbols in the rule, those shown in table 4. These symbols cause the algorithm to compare each context symbol in the rule to the categorical symbols assigned earlier to the characters in the input string. Again, should the algorithm encounter a failure in a match attempt, it will proceed to the next rule.

When the phoneme conversion is complete, the routine collects values for intonation and stress characteristics in other buffers. The parameters involved are those for pitch inflection, output amplitude, speech rate, filter frequency, rate of inflection transition (slope), and rate of articulation transition (slope). These last two parameters are not stored in separate buffers but as one nybble of parameters in the speech-rate and amplitude parameter buffers, respectively. A detailed explanation of these parameters appears in table 5.

Interpreting the Rules

Let's look at a few sample cases of the phoneme rules. For instance:

!(A)! =0804

This rule states that a letter A preceded and followed by a nonalphabetic character (the "!" context) is to be pronounced by the phonemes A and Y1.

The exclamation points indicate that on both sides of the A are one or more nonalphabetic characters, which can be a space, punctuation mark, number, or any symbol other than an alphabetic letter. For example, the A in the string "1A " would be pronounced according to the above rule since it meets the conditions indicated. The strings " A ", "A%", and "$A?" would all match the above pattern.

When putting another rule into a subtable, you must carefully consider the exact position of that rule because the algorithm takes the rules in sequence. If the conditional parameters of two rules were similar, it would be possible for sequential preference to cause the wrong rule to be selected for a given input string.

For example, it is possible that "YOUR" would be pronounced like "you-are" if the rule for "YOU" preceded a specific rule for "YOUR", because the rule for "YOU" would be accepted before the rule for "YOUR" was even considered, so the rule for "YOUR" would never be evaluated. (After accepting "YOU", the algorithm would next search the "R" subtable for a rule to satisfy "R" in the last position.)

To avoid such errors, clearly the rule for "YOUR" must precede the rule for "YOU"; "YOU" would not be mispronounced by the first rule since the trailing "R" would cause a no-match situation. The algorithm would continue to search the subtable until it reached the rule for "YOU".

The example given above for the letter A is tightly defined, and the pronunciation appears to be an exception to a rule that is more generally applicable, which comes next in the table:

Duration/Phoneme
This parameter contains the actual phoneme code. The upper 2 bits of this value designate the duration of the phoneme. The real-time duration varies depending on the value of the speech-rate parameter.

Inflection
Of the several modes of inflection that could be used, only the transitioned inflection mode is used by the text-to-speech algorithm. In this mode, there are 32 target values for the pitch of the spoken output. The output signal moves smoothly from one target value to the next.

Speech-Rate Inflection Slope
This controls the rate at which speech is produced. The lower 3 bits control the rate of inflection transition.

Control Articulation Amplitude
The upper bit controls the mode of operation of the chip. The next 3 bits control the rate of articulation transition. The lower 4 bits control amplitude.

Filter Frequency
Controls the vocal-tract filters. Different values will instantaneously shift the frequency of all formant filters.

Table 5: *A detailed explanation of the parameter bytes used by the text-to-speech routine for pitch inflection, output amplitude, speech rate, filter frequency, rate of inflection transition, and rate of articulation transition.*

1!(A)! =0804
2(A)! = 1A

The second rule states that "A" in the input string followed by a nonalphabetic character is to be pronounced as the phoneme UH (hexadecimal 1A represents UH). The second rule does not specify anything in particular to the left of "A". Therefore, as long as "A" is merely followed by a nonalphabetic character, this pronunciation will be used. Note that if the rules were reversed, the rule !(A)! would never be reached because the (A)! rule would match its patterns.

Although rule 1 above is rather narrow in scope, the class of nonalphabetic characters comprises a number of different symbols, and even more specific rules might sometimes be needed. For example, if you found that the pronunciation for the input string "A?"was too short, a rule could be created to deal with this, as follows:

!(A?) =080404

This rule would have to be placed before !(A)! in the table because having a question mark following the "A" is an exceptional condition. Any other nonalphabetic symbol would not match the question mark, and the algorithm would proceed to the next rule.

In addition to adding new rules, you may delete any rule within the range of the subtable, with the exception of the last rule. (Each subtable must have at least one rule, even if its input character is to produce no sound.) All rules following the deleted rule will move up one position, reducing the rule count and number of bytes accordingly.

The text-to-speech software provides a convenient test mode as part of the rule editor to let you evaluate any changes made to the rule tables.

The Rule Editor

The rule-table editor provided with the text-to-speech algorithm allows complete control over the rules that govern the conversion of input text into phonemes.

The rule table contains all alphabetic characters, all numbers, all punctuation marks, and all printable special-purpose symbols. (Control characters are not included.) Although the number of rules in a table is unlimited (insofar as the disk storage and memory capacity will allow), extremely large tables will cause the conversion process and the output of speech to slow down.

When the rule editor is in use, the

(6a) Key	Function	Key	Function
D	delete an entry	S	select new subtable
E	edit an entry	T	test mode
H	help menu	U	update main rule table
I	insert a new rule	Control-P	print current subtable
Q	quit or exit program	Control-S	save rule table to disk
(space)	advance to next page of current subtable (if any)		

(6b) Keys	Command	Function
Control-A	(amplitude)	set amplitude level (0–11)
Control-F	(filter frequency)	set filter frequency (0–253)
Control-I	(inflection)	set inflection level (0–25)
Control-R	(speech rate)	set speech rate (0–13)
Control-X	(help)	display brief introductions
Control-Z	(return to editor)	exit test mode

Table 6: *The rule editor provides a set of editing functions (6a) and a test mode with several commands (6b) consisting of control characters.*

screen shows up to 10 of the rules in the current subtable (see photo 2). If the subtable contains more than 10 rules, the program lets you scroll through the rules 10 at a time, wrapping around to the first set when the end of the rule list is reached. A list of rule-table editing functions is shown in table 6a.

The test mode allows you to enter any word or phrase up to 239 characters long, including punctuation marks. The algorithm then converts the input phrase into phoneme codes, based on the rules currently in the rule table, and instructs the Sweet Talker II to speak the codes. Commands available in the test mode are control characters as shown in table 6b. To make the rule-table changes permanent, the rule table must be saved to disk after an editing session.

Intonation

Perhaps the best way to see how the text-to-speech routine deals with indications of varying intonation and stress is to provide examples of usage. When entering text to be spoken, you can indicate what words or syllables are to differ in stress by setting them off with slash marks ("/").

For example, the string of characters

HELLO

would be pronounced with monotone inflection. But the string

/HE/LLO

would produce stress on the first syllable, while the string

SSI263 Registers

The registers discussed below are listed with their bits in order of decreasing significance.

Duration/Phoneme Register 0

DR1 DR0 P5 P4 P3 P2 P1 P0

The duration/phoneme register, D/P, is an 8-bit register where the 6 low-order bits (D5 through D0) designate one of 64 phonemes (P5 through P0). Table 3 on page 33 lists the 64 phonemes produced by the SSI263. The 2 high-order bits of the D/P register (DR1 and DR0) control the duration (timing) of the phoneme called out by the 6 low-order bits (P5 through P0).

Inflection Pitch Register 1

I10 I9 I8 I7 I6 I5 I4 I3

The inflection register is an 8-bit register (D7 through D0) where all 8 bits (I10 through I3) set or determine the rate of movement of inflection pitch. There are two modes of implementing inflection: transitioned *inflection and* immediate *or instantaneous inflection. Immediate inflection causes the current output to instantly take on the value corresponding to the 8-bit code in the inflection register and the 4-bit code in the R/I register. The total of 12 bits in these two inflection registers gives a range of seven octaves on an even-tempered scale. The immediate mode is useful for singing, musical sound effects, and for fine-tuning a duplication of human inflection.*

Rate/Inflection Register 2

R3 R2 R1 R0 I11 I2 I1 I0

The rate/inflection register, R/I, is an 8-bit register where the 4 high-order bits (D7 through D4) designate one of 16 (R3 through R0) overall settings of speech/sound-effects rates and A/R timing response. The 4 low-order bits (D3 through D0) of the R/I register (I11, I2, I1 and I0) are 4 bits of inflection that are always in the immediate mode. In combination with the 8 bits of inflection from the I inflection register, I2, I1 and I0 are the 3 low-order bits of the 12-bit counter-inflection chain, and I11 is the MSB (most significant bit).

Control/Articulation/Amplitude Register 3

CTL TR2 TR1 TR0 A3 A2 A1 A0

This 8-bit register, C/A/A, has three functions. The 4 low-order bits (D3 through D0) designate one of 16 (A3 through A0) amplitude levels of the analog audio output (AO, pin 1). The MSB (D7) of this register (C/A/A) is the control (CTL) bit. When this bit is found to be high, the SSI263 is powered down. The remaining 3 bits (D6, D5, and D4) of the C/A/A register (TR2, TR1, and TR0) determine the rate of movement of the formant position for articulation.

Filter-Frequency Register 4

FF7 FF6 FF5 FF4 FF3 FF2 FF1 FF0

The file-frequency register is an 8-bit register (D7 through D0) in which all 8 bits (FF7 through FF0) instantaneously set or shift the frequency of all the vocal-tract filters (formants), which can produce an effect similar to slowing down or speeding up a record player, but with a greater range and without affecting inflection (pitch) or other SSI263 timing. With a setting other than the normal one for speech, the filter-frequency register can raise or lower the vocal-tract filter frequencies to create sound effects.

HELL/O/

would put stress on the final "O". The program is smart enough to consider punctuation in setting inflection. The text string

HELLO?

would be pronounced with a rise in pitch at the end, and the string

HELLO.

would be sounded with a drop in pitch at the end.

The algorithm looks for pairs of stress markers; it can ordinarily be overridden only by proper terminating punctuation, such as a period or question mark. The type of terminator determines the slope of pitch inflection at the end of a phrase or sentence. Multiple pairs of stress markers can be used to set the starting level of inflection and to specially emphasize any subsequent stressed portions of the remaining phrase or sentence.

Figure 4 depicts the inflection pattern for a single pair of stress markers. The inflection level begins at the default of level 2; it continues at this level until the program encounters the first stress marker, where it raises the pitch to level 3. The inflection level remains at level 3 until the program finds the second marker. After the second marker is found, the program looks for the terminator at the end of the clause. The inflection level will be raised or lowered at the end depending on the type of terminator. If no terminator exists, then the algorithm assumes that it should glide the pitch down (as in a declarative statement), but the glide will begin at a later point than otherwise. The maximum value of the up or down glide is predetermined; if the limit is reached prior to the end of the phrase or sentence, it will continue at that level.

Let's take a look at some real examples:

/HOW/ ARE YOU?



Photo 2: *The rule editor for the text-to-speech software displays the phoneme-translation rules for each letter in groups of 10.*

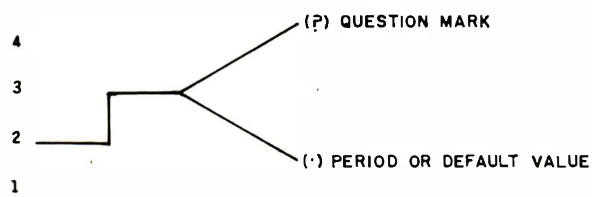


Figure 4: *The inflection pattern for a single pair of stress markers, as used by the text-to-speech routine to identify where to change pitch.*

"HOW" is stressed; its pitch glides up to the fourth level until the limit is reached or the terminator is encountered.

HOW ARE /YOU?

A simple system of stress markers allows specification of intonation and stress.

The word "YOU" is stressed in this case; the pitch then continues to glide up until the end of the sentence. Since the algorithm finds the interrogative terminator before anything else happens, the glide also stops at that point. In this case, the sound produced for the word "YOU" is very short. It is so short that the algorithm may not have time to react to the stress marker and initiate a glide before it encounters the terminator. The result may be an abrupt rise in pitch. Greater and more significant differences may be seen in the following example:

DID YOU /SEE/ THAT?

The effect of the stress markers and question mark works extremely well in this particular case.

The question-mark terminator has two possible effects on a sentence. In general, the question mark causes the pitch inflection to glide up at the end of a sentence, with one exception. The algorithm looks for questions whose first word begins with

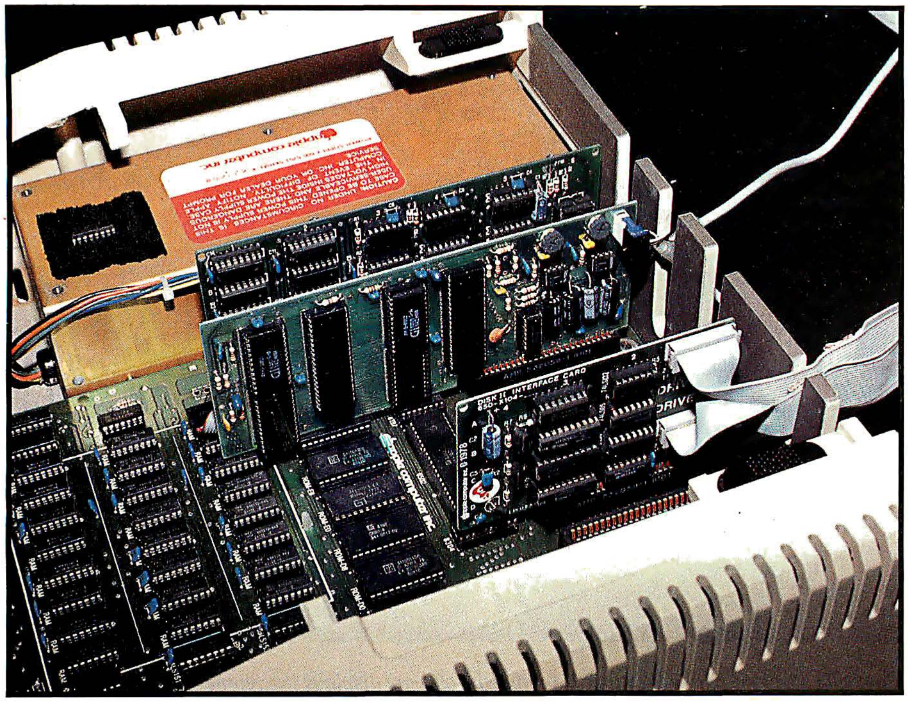


Photo 3: *The latest version of the Mockingboard music-synthesis system has two sockets into which SSI263s can be plugged. The speech synthesizers can then sing along in stereo. The Mockingboard is a product of Sweet Micro Systems, 50 Freeway Dr., Cranston, RI 02920, (401) 461-0530.*

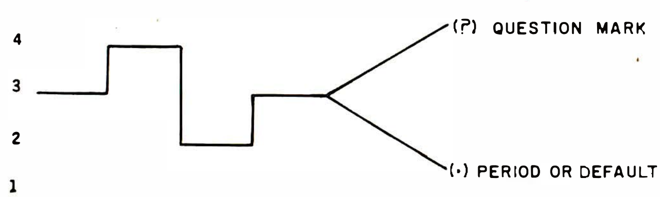


Figure 5: *The pitch inflection follows the pattern shown here when the algorithm encounters multiple pairs of stress markers.*

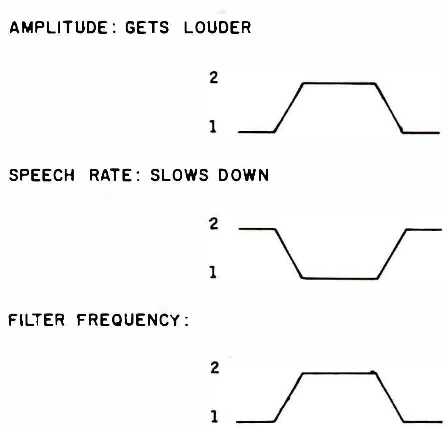


Figure 6: *Not only is the pitch raised for stressed syllables, but the other speech parameters are altered as well.*

"WH". In such cases, the glide at the end of the sentence should be down. For example:

WHAT /WAS/ THAT?

When the algorithm encounters multiple pairs of stress markers, the inflection follows the pattern in figure 5. In figure 5, we can see the inflection pattern beginning at level 3 and continuing until the text-to-speech routine finds the first stress marker. The level then goes to level 4 until the routine finds the second marker. At that point, the inflection level drops to 2, where it stays until the third marker is reached. The inflection level then goes up to level 3 again and remains until another marker or the terminator comes along.

As a general rule, the first syllable in a clause is stressed to a greater degree than subsequent syllables. This inflection pattern does not take effect if a compound sentence contains multiple pairs of stress markers or clauses separated by commas. Commas are also considered terminators, so the clause preceding the comma will be treated separately.

The other speech parameters besides pitch are also altered, in a rather consistent and straightforward manner, when a syllable is being stressed. Their changes are shown in figure 6.

In Conclusion

I haven't mentioned many uses for speech synthesis, but I'm sure you have a few ideas for what you could do with a speech synthesizer. I hope you now appreciate the amount of vocal power currently available at a relatively low price. The SSI263's highly intelligible speech promises new applications for computers, and the Sweet Talker II will likely enjoy a lot of indirect software support because of its compatibility with other SSI263-based speech synthesizers.

The invention of SSI263 does not mean the demise of other approaches to computer speech. But it introduces low-cost speech output into fields that could never previously have justified the expense.

Next Month:

The IBM Personal Computer can run BASIC programs as much as 100 times faster than normal using a coprocessor board. ■

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Steve Ciarcia is an electronics engineer and computer consultant with experience in process control, digital design, nuclear instrumentation, product development, and marketing. In addition to writing for BYTE, he has published several books. He can be contacted at POB 582, Glastonbury, CT 06033.

Special thanks to Rod Nakamoto for his contributions to this project. Technical data on the SSI263 speech synthesizer reprinted by permission of Silicon Systems Inc., 14351 Myford Rd., Tustin, CA 92680, (714) 731-7110.

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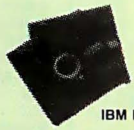
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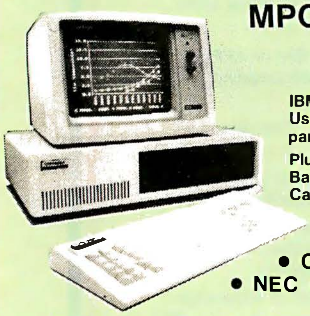
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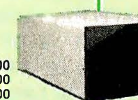
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New Machines, Networks, and Sundry Software

Chaos Manor is inundated with new computers

by Jerry Pournelle

We've got three new machines—four if you count the IBM PC, which arrived only a month ago. Alas, the work load at Chaos Manor has come in a flood that threatens to drown us, and we haven't yet been able to get a new editorial assistant on board, so there's not been as much hacking about with the machines as I'd like.

Meanwhile, things are happening in micro land. The winds of change are blowing again, and it's a bit hard to look far ahead. Even so, we can spot some trends.

First, though, the Corvus.

Corvus

The Corvus Concept is a fairly revolutionary piece of equipment. Corvus calls it a "workstation," which is to say that not only is it a full computer based on the Motorola 68000 chip, but the company has also paid a lot of attention to making it communicate with other equipment.

The Concept is an 8-MHz machine with 512K bytes of memory, a 720 by 560 bit-mapped display, a well laid out Keytronics keyboard that looks an awful lot like an IBM Selectric, a hard disk, and a bunch of communications ports. The screen is unusual: it's taller than it is wide, or it can be laid on its side so that it's wider than tall. The monitor is a big Ball Brothers that feels like it weighs a ton; you want hefty furniture, and don't expect to carry a Concept around very much.

I'm very fond of the detached keyboard, and I like the character set used on the screen. Being bit-mapped, it can show **boldface** and *italics*. The machine comes with a text editor called "Edword." The name is a horrid pun, but the editor itself is quite nice, sort of a well-tamed EMACS with lots of dedicated keys. The editor continuously updates the disk file every 30 seconds or so. That takes less than a second to write to the hard disk; it's not particularly distracting. This means that power failures, or playful kittens, can't lose you more than a few seconds' worth of work. Edword (ye gods I hate that name!) keeps a complete disk file of everything you've done, so that there's a full Undo function; enough presses of Undo will get you right back to a blank screen.

The operating system and disk formats are Corvus's own, of course, and are going to require more study. So far, I've used UCSD p-System and CP/M-68K on the Sage and CP/M-68K on the Compupro 68000. I think I prefer Corvus's own operating system to the other two, but that view is based on far too little experience to put any confidence in.

One feature I like in the Corvus is a Suspend key; pressing it will let you do other tasks, such as communications through the modem, after which you can resume editing or whatever.

We're always concerned about hard-disk systems. Some, like the Kaypro 10, must be shut down in a particular sequence that retracts the disk head to what's called a "landing position." There wasn't any obvious shutdown procedure for the Corvus, so Alex called David Ramsey of Corvus to ask how to turn the machine off.

"Set all switches to the 'off' position," was the reply.

While we were on the phone the wind came up, and we had two short power failures, with power restoration too quick to allow us to turn off the machine, so that the Corvus disk powered down and back up unattended. The Corvus never lost a single byte of data and is unharmed.

By contrast, there seems to be a newly developed bad area on the Kaypro 10's hard disk; we don't know if this is related to the spate of storms and power failures we've had this month, but it might be.

There's a lot to like about the Corvus, and you'll certainly be hearing more about it in future columns.

I confess that until I began playing with its new machinery, I wasn't much impressed with the company; but the Concept has completely changed my view.

Alex has done more with the Corvus than I have. His notes open with, "I think the Concept is great!" He's also anxious to see Corvus's Unix for the 68000 Concept, which it claims will be available Real Soon Now. At COMDEX, Corvus showed off its new "gateway" to the IBM SNA (System Network Architecture); that plugs into the Corvus Unix engine, which is a 68000 box something like the Concept but not quite. The company will also be adding an interface to Ethernet.

Networking

Computer networks are the coming thing. Individual micros are powerful enough to do most of the work needed by small businesses, but not *all* of it. In particular, micros can't store and easily retrieve huge gobs of data, and of course they're limited in the number of data sources that can be active.

The obvious solution is to connect a bunch of micros together. Networking has long been done with big mainframe machines and minicomputers; it's harder to accomplish for micros than it sounds. Of course, one might use the same kind of network interface for micros that is used on minicomputers. One of the most popular is Ethernet, developed by Xerox. The problem is that an interface board to couple any machine to Ethernet will cost about $1000, which is trivial compared to the cost of a big mini but is no small sum for micro users.

One of the Concept's strongest features is communications. The machine comes with an Omninet interface; we also have Omninet interface boards for the IBM PC, the Apple, and our S-100 system. Omninet uses a twisted pair of wires and will run up to 2000 feet between workstations. Alex is even now stringing wires through the house. With luck, we'll soon have all the major machines in Chaos Manor connected to the Corvus hard disk.

Corvus believes in Omninet. Its new headquarters in Silicon Gulch is wired for communications: coaxial cable between buildings, Omninet inside each. Corvus will use its "SNA gateway" box as an interface between other kinds of computer networks. The "gateway" looks a lot like the bottom part of a Concept. It has big slots for an Ethernet board and small slots for Apple boards. For that matter, the Concept has four Apple-type slots in back. We're told that most Apple boards, including 5¼- and 8-inch disk controllers, will run in those.

If you listened in the right places at COMDEX, you could hear rumors of an IBM multiuser machine that would be the big brother of the IBM PC. If that's truly in the works—and it makes sense—then a network officially supported by IBM wouldn't be far behind.

With luck, we'll soon have all the major machines in Chaos Manor connected to the Corvus hard disk.

An IBM "big micro" would surely be built around a larger chip than the 8088 used in the PC and PCjr. Since IBM owns some 15+ percent of Intel, it's likely to be one of the new Intel family, possibly the iAPX286, or even the 486, unless the production problems Intel has had lately persist longer than I think they will. Whatever IBM uses, I suspect the "Super PC" will connect downhill to the PC and uphill to IBM mainframes.

What net might IBM use? It has several choices.

(1) It can go with the fast but relatively expensive Ethernet. If Big Blue does that, Ethernet will be "legitimized," with some drop in prices as a result of increased volume of sales. The most popular IBM PC Ethernet interface is based on one very complicated chip, so hardware prices have the potential to drop.

On the other hand, the low-cost net designers won't give up. Omninet will get a fair amount of business, because Omninet can hook into Apple and other machines incompatible with Ethernet. Besides, if Ethernet can be put on one (expensive) chip, the less expensive nets can be put on a single (cheaper) chip as well. There'll also be a scramble to build gateways to the IBM network.

(2) It can go with an existing low-cost net system like Omninet, Arcnet, or some other RS-232C-type network. This doesn't seem likely: IBM would be just another competitor in an already crowded market.

(3) It can go with its own expensive network. This is certainly consistent with IBM's past actions. It wouldn't be a popular choice among users, but that hasn't concerned IBM in the past.

(4) It can devise its own cheap networking system. This is a nontrivial R&D task even for IBM; but it would certainly have a major effect on the market, causing a big shakeout and cleanup. Alex doesn't think this alternative is likely, and I'm inclined to agree.

Networking Really Is Important

Why worry about networks? Businesses and hackers alike will want them. There's so much appeal for business in a network that links incompatible machinery—such as Apple, IBM, Kaypro, Eagle, Corvus, etc.—that "independent" networks will flourish no matter what IBM does. For example: once we have Omninet set up, I'll be able to transfer files among the Apple, Corvus, Compupro, Z-100, and IBM PC machines, neatly solving a number of the disk-format problems that have plagued us for months.

Networks will be forced upon the bigger companies just to increase productivity. Some businesses may resist, but that will stop the day the managers of Company A find that all of Company B's employees know of A's newest developments before all of A's people know.

In fact, there's going to be a thriving business in building gateways between various popular networks, and outfits like Corvus are getting a head start. A black box that interconverts all networking protocols will be mandatory when a business wants to con-

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nect several "unfriendly" networks.

Some years ago, Digital Research sold something called "CP/Net" that allowed CP/M machines to talk to each other. We had a copy here at Chaos Manor, but we never had it running. CP/Net languished within Digital Research, getting little support or sales, and in early 1983 Digital Research quietly removed it from the market, neatly stranding several outfits who'd signed up for the 16-bit version. In theory, Digital Research will support CP/Net, although the company no longer sells it. In practice, that support is minimal.

At this fall's COMDEX, DR announced "Soft/Net," its new network. Unlike hardware manufacturers who sponsor networks built around one particular kind of network hardware, DR plans to support *all* the major networks, including Omninet, Arcnet, and Ethernet. (In fact, DR had TI Professionals, IBM PCs, and Compupros talking to each other in its booth at COMDEX.) This is a clever move, since there's no clear-cut network leader. If IBM announces a micro network, DR can quickly add it to its stable—always assuming that Digital Research doesn't already know what Big Blue plans. There's some evidence that it does, as we'll see later.

Soft/Net is supposed to connect to both 8-bit and 16-bit micros running CP/M, CP/M+, CP/M-86, and Concurrent CP/M. The network is supposed to look just like any other disk or printer to the computer; current software should run without changes. In theory, that will end disk-format incompatibilities: put your files on the central disk drive and use PIP to move them to another machine. Soft/Net should also be a big boon to bulletin-board operators.

DR promises all the usual trimmings to go with Soft/Net: file sharing, password protection, record locking, and file locking. (File locking means that no one else can write to a particular file while you're using it; record locking write-protects only specified records within a file.) If DR can make this work, it will be tremendously popular and successful. I believe that Concurrent CP/M will replace PC-DOS in the IBM PC world; add Soft/Net, and DR will have given the micro world a new de facto standard. The computer world desperately needs a software network that works with *all* the other popular networks; we wish Digital Research well in this effort.

Operating Systems, Past and Future

When microcomputers first came out, there were oodles of different operating systems, and the only way our computers could talk to each other was by (ugh!) paper tape. Then came the CP/M revolution, and suddenly hackers with machines made by different companies could communicate simply by swapping disks. CP/M quickly became the de facto standard.

For a while, few doubted that CP/M with upgrades to 16-bit systems would continue to be the standard; then came IBM. For some reason, Digital Research didn't sign up IBM, and Microsoft's PC-DOS became the standard for IBM PC systems. CP/M-86 was available, but few bought it.

The original PC-DOS had remarkable similarities to CP/M 1.4. However, the commands for PC-DOS were quite different from CP/M's, in some cases being precisely backward. PC-DOS also suffered from CP/M 1.4's major limitations, and many programmers muttered that it wasn't truly an operating system; it was merely a job-control language. It was obvious to most that vanilla PC-DOS wasn't long for this world. Changes would be made.

The inevitable was delayed a bit by embellishments to PC-DOS; incidentally, that made PC-DOS less and less like MS-DOS, increasing the babel in 16-bit land. Even so, PC-DOS has too many limits. Something's going to give.

There are several possibilities.

Unix

Unix, for the tiny few who don't know, is a multiuser, multitasking operating system developed at Bell Laboratories. Multitasking means that one user can do several jobs at the same time, with some interconnection between the jobs; multiuser allows more than one person to use the computer, not all that useful for a micro: better, I'd think, to have "one user, one computer." Multitasking, though, is *very* useful.

It seems that Unix System 5 is going to be very different from Xenix. As a result, Microsoft will not be writing a version of System 5 for Intel for the iAPX286. Instead, Intel has contracted for a version of System 5 from Digital Research. Xenix's position in the marketplace may now be somewhat less secure than it once seemed.

Unix probably would have become commercially popular, but Bell had some legal problems involving antitrust, so the price tag was kept very high—except for nonprofit users. These latter could buy Unix for trivial bucks, and did, so that a number of computer science students learned to use Unix, and many came to love it.

We've heard rumors of Unix for micros since the late 70s. The rumormongers are usually very positive. "I can't wait," and "Wow, will you love Unix!" are typical. A few detractors mutter that users had better be prepared to know more than they want to about their computers; Unix lets you do a lot more than CP/M does, but before you can do *anything* you must learn more about Unix than you'll ever need to know about CP/M.

I won't get into that debate here.

For one or another reason, a series of "almost Unix" systems were developed, the best known of which was Xenix.

Meanwhile, a few outfits, such as Charles River Data, have a real live Unix clone (called Unos) on their MC68000 systems. After the first of the year, when, for reasons never clear to me, we're going to dismantle the world's best-run telephone company (have you ever tried to make a phone call in Paris?), Unix will, we are told, be a lot cheaper for ordinary businesses; some predict a rush to Unix. Others are more skeptical.

At the moment, there's no clear "standard" operating system for MC68000 microcomputers. Unix may take over that spot.

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One prediction I can make with confidence: you won't see "vanilla Unix" anywhere a business user can get at it. Straight from the box, Unix is user-threatening. Unix is very adaptable, though, and can be surrounded with a very friendly command structure "shell."

Concurrent CP/M 3.1

A major contender for supremacy in the PC-compatible world is Digital Research's Concurrent CP/M-86, which I'll call CCPM.

CCPM has a lot going for it. For one thing, it's file compatible with CP/M 2.2, meaning that it's possible, if nontrivial, to transfer files written on 8-bit machines up to your PC-compatible 16-bit equipment. This is important for companies planning an upgrade from 8-bit equipment.

Second, CCPM is multitasking. That is, you can be working with your text editor, go do some calculations, drop that to start printing a file, let that be printing and start a long compilation, and leave the compiler going while you return to your text editor as if you'd never left it. This is such a nifty feature that anyone who uses it will never understand how he got along without it.

Even so, CCPM hasn't quite caught on, largely because so much PC-DOS software is out there, and there were a few difficulties with early versions of CCPM.

Have no fear. Concurrent CP/M-86 3.1 is here.

The new CCPM is not only multitasking, it is also multiuser, which means it looks an awful lot like Unix. Indeed, you can recompile most CCPM programs and they'll run under the Unix operating systems that are being developed in various skunk works in Silicon Valley.

More important, CCPM 3.1 emulates PC-DOS: that is, along with CCPM you can get an enhancement that will let you, as one (or more) of the multiple tasks CCPM is capable of, run PC-DOS programs right out of the box. Now there are limits, of course: programs that are hardware specific to the IBM PC aren't going to run on anything but a PC. However, all the PC-compatible software will

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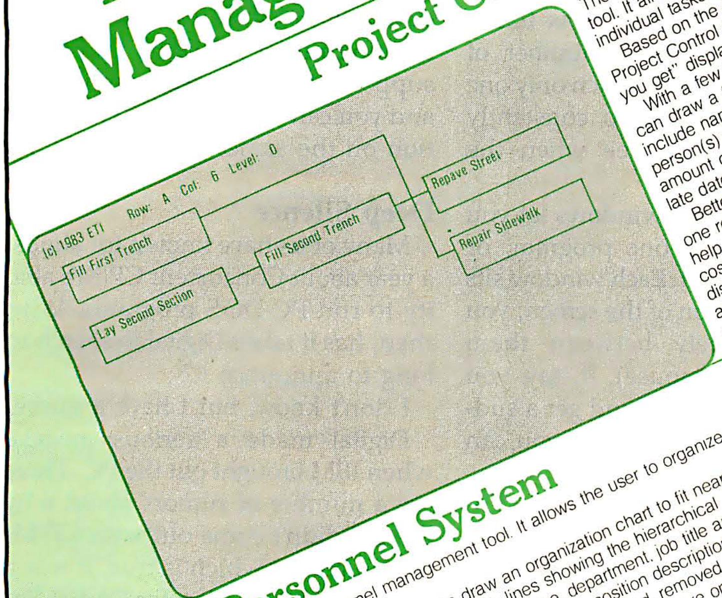
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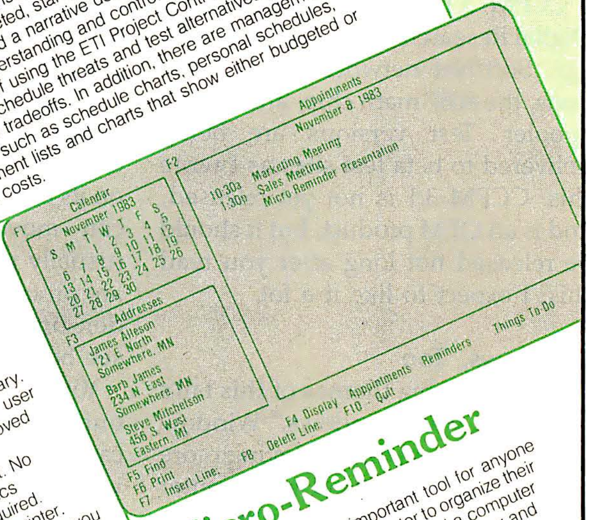
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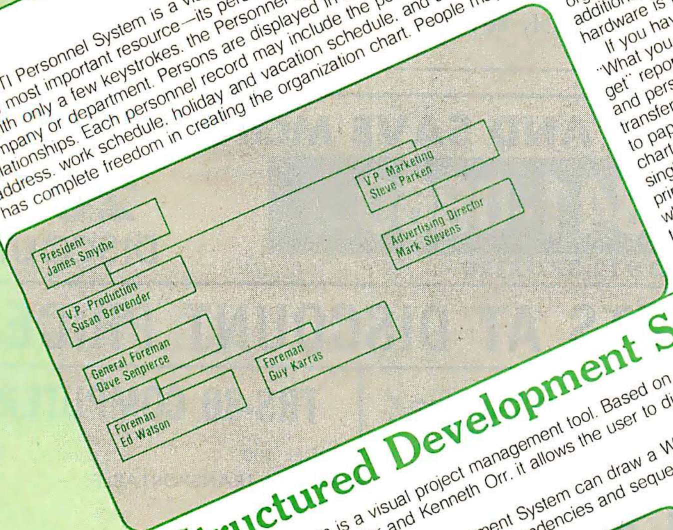


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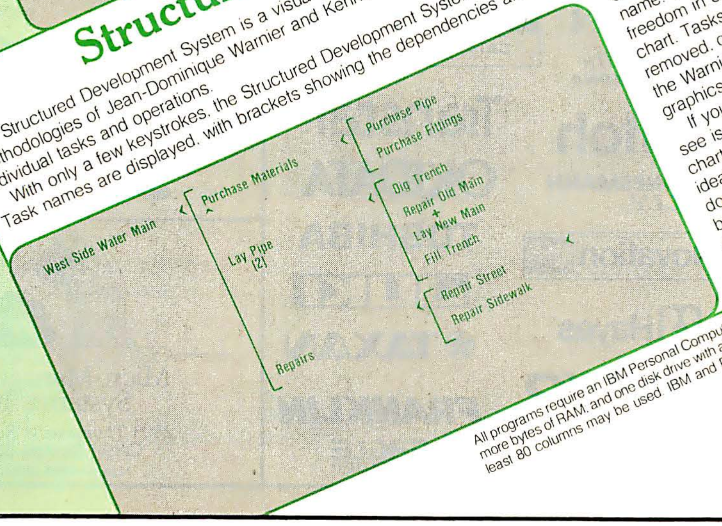
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If you have a printer, "What you see is what you get" reporting of all charts and narratives transfers your ideas to paper. If the Warnier chart does not fit on a single page it will be printed on multiple pages which may be taped together to form a complete chart.



All programs require an IBM Personal Computer with monochrome display running PC-DOS, a memory of 128K or more bytes of RAM, and one disk drive with at least 256K byte capacity. No printer is required, but any printer with at least 80 columns may be used. IBM and PC-DOS are trademarks of International Business Machines.

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run with any machine with CCPM. In particular, we're getting it going on our Compupro Dual Processor, as well as on the Compupro 8086/8087 and the Eagle 1600. Also, Compupro is developing a PC-compatible video board for the S-100 bus; this will let us use even more PC-DOS software without modification. (That board should be available sometime in the spring of 1984.)

CCPM 3.1 will also support the Digital Research GSX graphics package, Soft/Net network communications, the 8087 math chip, and a print spooler. Test versions are being delivered to beta test sites as I write this. CCPM 3.1 is not yet released, and is an OEM product, but it should be released not long after you read this. I expect to like it a lot.

Windows, Too

One of the big themes of this fall's COMDEX was "windows." Window is a generic term for displaying more than one job (task) on a computer screen at once. Until recently, windows were available only on very expensive computers like the Xerox Star; then the Apple Lisa showed up. Since then, many companies have raced to put windows on the IBM PC.

There's a difference between windows and concurrency. The original Concurrent CP/M will run more than one task at a time, but you can watch only one at a time. This is like a television: you have a number of channels, but you can watch only one at a time. You have to constantly switch channels to see when the commercial is over.

With computers, windows let you watch more than one program, or channel if you will. Each window sits on its own portion of the screen; you can move freely between them (usually with a mouse). If, say, you are processing words and get a sudden urge to draw a graph, you can see both with windows.

You can also have windows without concurrency: that is, windows can be a screen feature to let you watch different displays, but they're all generated by the same program. Some of the most widely advertised "window" systems are that kind.

The newest version of Concurrent CP/M has both: you can start a long assembly, and while that's running, open a new window to start an entirely different program, while leaving a window open on the assembly. You could then open another window and use it to watch a program running under PC-DOS. CCPM 3.1 supports up to four concurrent tasks, and you can watch them all in operation on the same screen.

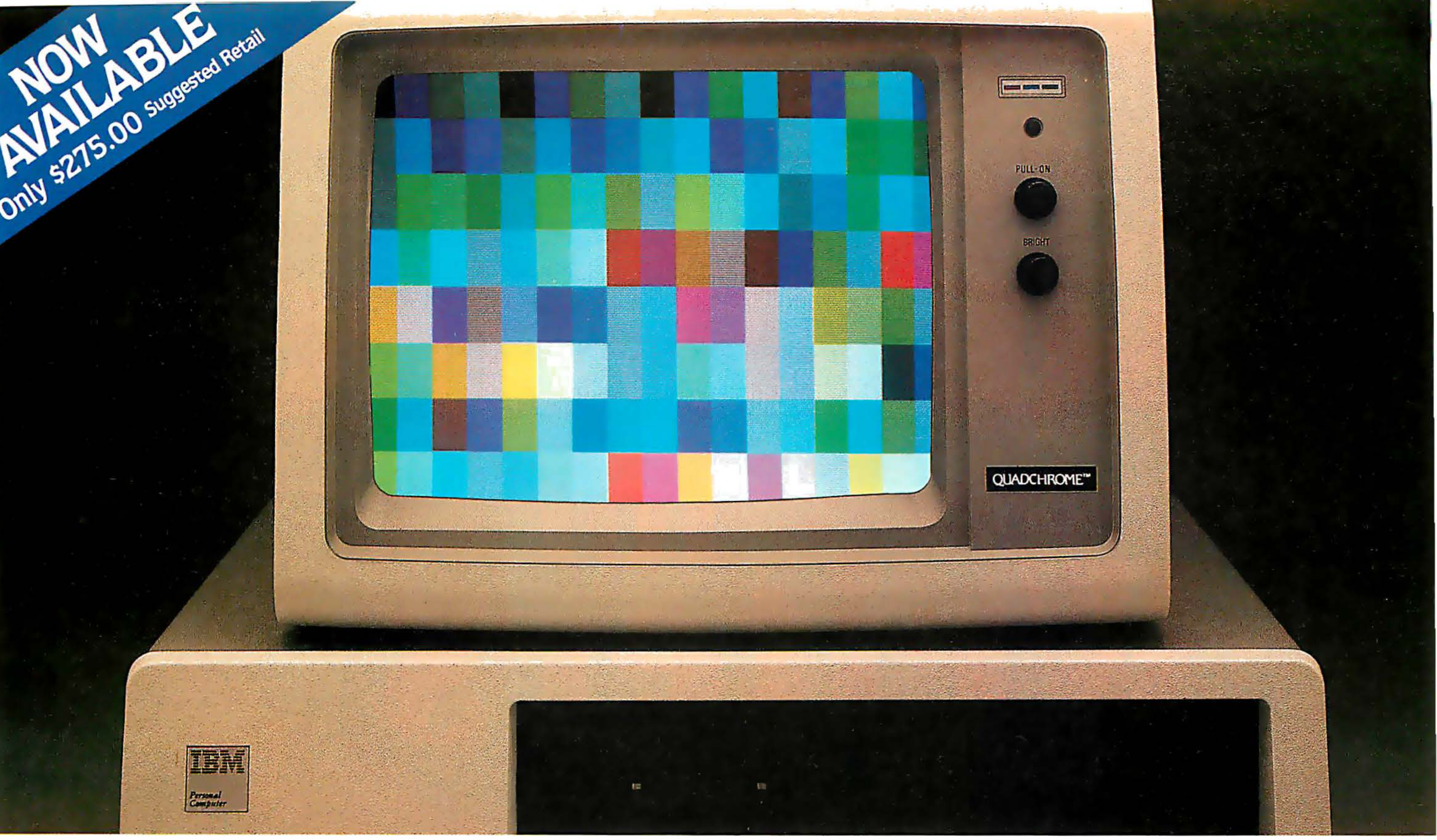
Deep Silence

Many of us have known for almost a year about Concurrent CP/M's ability to run PC-DOS programs. Why, then, has it taken Digital Research so long to announce it?

I don't know, but I have a guess.

Digital made a serious mistake when IBM brought out the PC. There are a number of rumors about why the PC didn't come out with CP/M-86. No matter which is true, it was a very serious situation for Digital Research. It had been the de facto standard, and suddenly it was only a far-

Text continued on page 58



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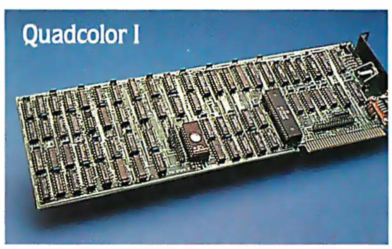
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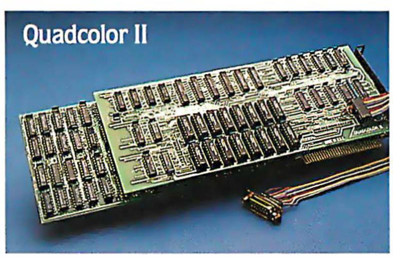
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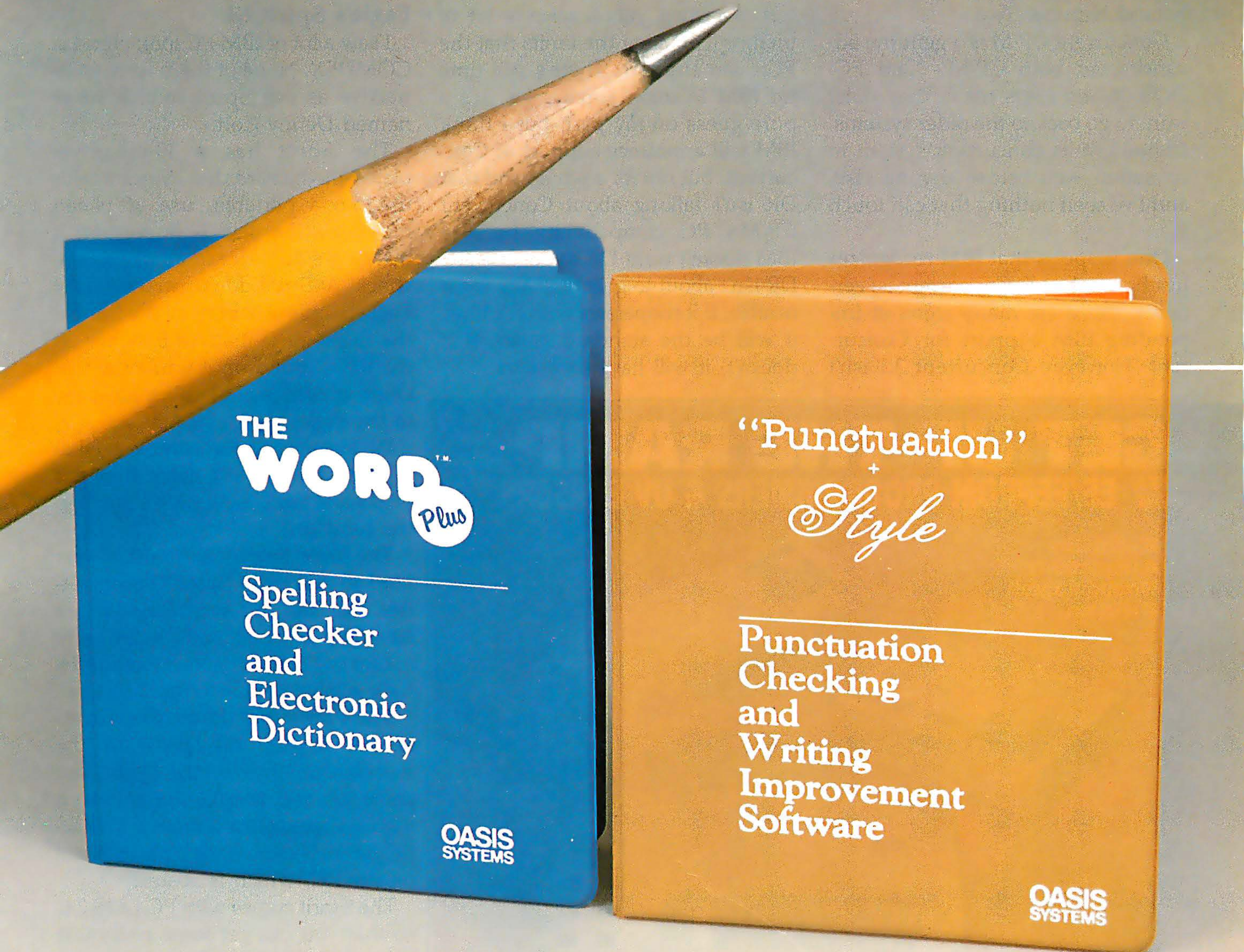
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Text continued from page 54:
behind Number Two.

Concurrent CP/M is a genuine advance over both CP/M+ and PC-DOS. When users try it, they don't want to go back to the older systems. Digital got its concurrent system in operation well before anyone else, and I've seen nothing that can touch it.

One suspects that IBM recognizes just how valuable Concurrent is; certainly, there are many signs of impending IBM support for Concurrent. However, Concurrent 3.1 isn't out of testing yet. It takes a lot of memory, pushing the limits that the PCjr can support. There's still time for IBM to make some sales. It's a pure guess on my part, but I think IBM will announce support of Concurrent, but not for a while, and that DR isn't talking about Concurrent CP/M's PC compatibility because IBM doesn't want DR to do that yet. DR isn't about to give IBM any more trouble. If it cooperates with Big Blue, it will be the standard again. If it doesn't, it will have problems.

Eagle's Spirit XL

I saw a lot of IBM PC look-alikes at COMDEX. None of them were as attractive as our Spirit, which we've named Denny Colt.

The Spirit has a 10-megabyte plated-media hard disk. Since it folds up into a portable, use of plated media on the disk is important: it makes the disk a lot more resistant to shock. At Spirit demonstrations, the Eagle people will pick up the front of the Eagle, raise it about 6 inches off the table, and drop it while the machine is running. Nothing happens to the disk.

We haven't had the nerve to do that to ours, but we did carry it to Las Vegas and back, with nary a glitch to the hard disk.

The Eagle people have worked very hard to make the Spirit PC compatible. All the PC software—quite a lot—they worked with runs as it comes out of the box. Next month I'll have a more detailed report on that.

There are minor differences. For example, Rogue, the game of the month, runs fine on the Spirit, but some of the graphics symbols it displays are slightly different. One little gizmo blinks on the Spirit but not on the PC, which is absurd.

The Spirit comes with PC-DOS 2.0, so that you can get some real value out of that hard disk. You may remember we had the Eagle 1600 with hard disk running under DOS 1.1, and since 1.1 has no user numbers or tree structure, it made it very hard to find anything on a 10-megabyte disk.

Hope at Last!

DOS 2.0 is also available for the Eagle 1600, and indeed you can be sure it runs on it, because the company used an Eagle 1600 as the development machine to get 2.0 running for the Spirit. Eagle has some brand-new ROMs and new operating-system software for the 1600; the machine improves constantly. The Spirit documents are incomparably better than the 1600's documents were; and since the 1600 was the development machine for the Spirit, it should be simple work to revise the Spirit documents to reflect the pecu-

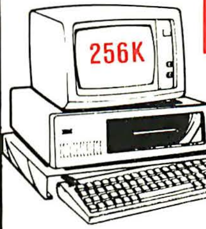
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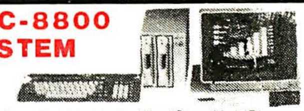
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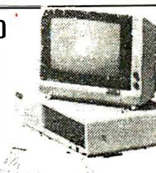
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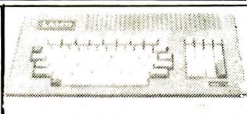
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liarities of the older machine. I expect Eagle to send some new 1600 documents Real Soon Now, and I'll certainly be glad to get them.

One defense Eagle has about the 1600 documentation: it advertised the machine as good for word processing and spreadsheets, both of which it does faster and neater than the IBM PC can do them; and those tasks are well documented. It was only the system features that it didn't tell us about.

The argument is valid, I suppose, but it doesn't impress me much. The 1600 is too good a machine to have been put out with those lousy documents. Indeed, with proper documentation, the Eagle might be the best PC-compatible software-development system on the market. Fortunately, Eagle is, at last, getting out manuals worthy of the machines they describe.

Rogue

Rogue is an Adventure-like computer game for the IBM PC. Unlike the original Adventure, the Rogue dungeons are randomly generated each time you play, so that no two games are ever alike.

It isn't played entirely like Adventure, either. For one thing, you move your character around on the screen with the cursor arrows (or with a mouse; the Logimouse works fine). Commands are menu driven; there are an awful lot of them, things like "q" for quaff a magic potion you may have found, "w" for wield a particular weapon, and such. You can read scrolls, put on rings of power, change weapons, change armor, and like that.

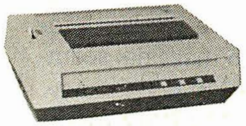
I hate to confess it, but the game is a real time trap. I found myself thinking "just one more try" far too often. The object of the game is to retrieve the Amulet of Yendor, but I haven't the faintest clue how one does that; I was killed every time, although once I got down to the fifteenth level and accumulated nearly 4000 gold pieces before a combination of trolls and quaggas got me.

Rogue is advertised as the most popular game running on Unix, and Alex says that's probably true. The

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MEMOTECH

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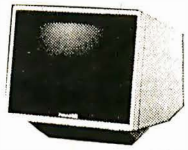
DMX-80	$389.88

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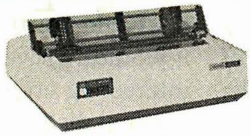
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Messenger

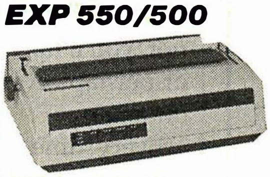


The Memory Correct III Messenger (12 cps) features 10, 12 & 15 cpi, variable line spacing, backspace, auto-correction and a dual parallel/RS-232C interface. True daisy wheel printing makes it an exceptional typewriter & printer. Ideal for the home or small office.

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EXP-550 (Par.)	$669.88
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Monitors

NEC



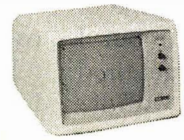
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PGS HX-12 (RGB)	$499.88

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US ROBOTICS

Password PC Modem

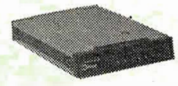
0-300/**1200 baud** direct-connect modem with auto-dial/answer, full/half duplex, voice/data. Uses LSI technology. Cables & power supply included (specify type of computer). The **PC Modem** has all of the above, plus a parallel port, real-time clock & memory to 256K.

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PC Modem	$CALL
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Circle 46 on inquiry card.

Artificial Intelligence Design Systems company has put it onto the IBM PC (requires 128K bytes of memory and a disk drive). It's also added a command called "S," for "Supervisor"; when you press that, the dungeon map vanishes, and a dummy of the PC-DOS operating system appears on the screen. This is intended to fool your boss into thinking you're working.

At one time, there were simultaneous Rogue games going on every PC-compatible machine in this house. It certainly was the game of the month. Recommended, but I won't be responsible if you get fired for wasting too much time with it.

Copy Protection

Longtime readers of this column will know that I don't much approve of copy-protection schemes. They're all right for games, but businesses *must* have backups of important software.

The argument for copy protection usually goes: "We have a $700 product here that can be copied in half a minute for five bucks. Of course we protect it." Which is all very well—until you ask the justification for charging $700 for something that can be produced for less than five bucks. The answer to that one often goes, "We put all that effort into software development, and when we sell it, people make illegal copies. We have to get a lot from each sale."

Fortunately, competition plus the expanding market base will drive the price of software down to something reasonable, say a small multiple of the price of a good book. Meanwhile, copy protection continues.

It's an evil practice. It's also futile. Let me give an example.

A number of programs designed to defeat copy protection are available. About the best I know of for the IBM PC is System Backup from Norell Data Systems. System Backup was written by a good friend who thoroughly understands the IBM PC; the program is revised as new and more clever protection schemes are devised.

I had a new version of System Backup at hand when Rogue arrived. I don't usually run master disks, so we routinely tried to make a copy. Wouldn't work. Rogue is copy protected. It's a game, so that's not so important; but I wanted to test the new System Backup, and Rogue was right there, so why not?

System Backup made a copy, but it reported a CRC error. We tested the copy on the IBM PC, and it seemed to work properly. Then we tried it on the Eagle Spirit. It worked there, but it wouldn't save the game. That was interesting enough that we tried the original disk on the Spirit; it worked fine, and indeed the copy can *read* a saved game; it just won't save one. On the IBM, though, the copy saves and reads and runs fine.

I gathered all the data and called System Backup's author. We agreed this was an interesting case. What, for instance, was the CRC error?

The problem, you see, is that copy protection involves putting carefully engineered errors into the system. A copy-protected disk has garbaged sectors, improperly formatted sectors, and such like; it also has a means for reprogramming the disk controller to allow it to find all, and only, the good sectors on the disk.

It's therefore impossible to tell whether an error on a copy-protected disk is a *real* error, caused by stray magnetic fields or spilled coffee, or a *contrived* error that's part of the copy-protection scheme.

Another problem: have the copy protectors thought everything through? They've reprogrammed your disk controller; do they undo that when you exit the program? If not, you'll have to reset the machine, or perhaps even turn it off and back on again.

Every time a publisher devises a new copy-protection scheme, a systems engineer will find a way to defeat it. That's inevitable: if the software can be made to load into the machine, then it can be copied. There is a class of systems engineer who *enjoys* defeating copy-protection schemes, much as Yardley enjoyed breaking codes. Any copy-protection scheme, no matter how elaborate, will be defeated—unless, in the effort

Text continued on page 66

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One computer.
Two points of view.
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Simplicity itself.
Or is it?

The plain fact is that the ease of operation the Epson offers today is accomplished with a degree of technological sophistication most other computers can only promise for tomorrow—specifically, fully integrated software, operating in an interactive environment.

The few other computers offering such "simplicity" cost $5,000 to $15,000 more. And most other computers can't offer it at any price. Which makes one wonder exactly what they do offer, in terms of either simplicity, or performance.

HOW MUCH CAN YOU DO ON THE EPSON? HOW MUCH ARE YOU READY TO DO?

The Epson's ease of operation may spoil you, but it certainly won't limit you.

Case in point: every Epson comes complete with an integrated software system—*Valdocs*®—to effortlessly provide the basic functions for which most people buy computers. The Epson also comes with *CP/M*®-80 2.2, so you can choose from the hundreds of programs in the CP/M library. And only Epson offers an exciting new collection of seven best-selling programs now specially enhanced to give you every powerful feature, plus Epson one-button simplicity. Included are *dBase II*,® *Friday!*,™ *Microplan*,® *Graphplan*,™ *WordStar*,® *SpellStar*,® and *MailMerge*.® And the Epson also allows you to add *MS*™*-DOS* compatibility, so you have access to best-sellers like *Lotus*® *1-2-3*.®

Best of all, you will run the software of your choice on the computer of choice. The high-performance Epson. With 256K RAM. 128K dedicated video memory. The breathtakingly sensible *HASCI*™ keyboard. Dual 380K double density disk drives.



Graphics capabilities unequalled in its price range. A high resolution monitor, 640 by 400 pixels, for clarity few computers in any price range can offer. Plus, an RS-232C interface, a parallel printer interface, and internal space for up to five peripheral cards so you can expand your Epson as your needs require.

One further point: all these features, and quite a few more, are included in the Epson's $2,995 price. Some com-

Text continued from page 62:

to make the software uncopyable, it's made so fragile that it's no longer reliable. That, alas, is all too common.

Programs like System Backup are revised each time a new copy-protection scheme comes out. They're one remedy for the copy-protection disease. Another is simply to stay away from publishers who are more concerned with their own protection than their customers' requirements.

Does That Suit You?

As I'm writing this, the radio tells me that the space shuttle *Columbia* will miss her morning landing, due to a glitch in one of the IBM general-purpose computers aboard the spacecraft.

I wonder what that will do to IBM's stock?

In any event, it reminded me of another computer aboard the ship.

I was, many and many a year ago, involved in full pressure suit design and testing, and indeed my Experimental Stress Laboratory at the Boeing Company did some of the crucial simulations that led to choosing the Goodyear suit for the Apollo mission.

Suit design is tricky. One doesn't want too much pressure in them, lest they blow up like balloons and become so stiff that the astronaut can't move. On the other hand, there has to be *enough* pressure to keep the astronaut alive. Finally, you can't have your astronaut go too quickly from 14.7 psi (pounds per square inch), which is standard atmospheric pressure, down to, say, 3.8 psi, which is about the minimum needed to keep the occupant healthy in a pure oxygen environment. Sudden pressure drops can cause lots of problems, including what divers know as "the bends," which is caused by nitrogen bubbles forming in the bloodstream.

That's another story. In any event, NASA sponsored several suit design efforts, but eventually the shuttle suits were produced by the Hamilton Standard Company. Before it was over, it had put a couple of hundred million dollars into building fewer than 50 suits. The cost overrun for pressure suits was a significant fraction of the total overrun for the shuttle program.

One of the features of the shuttle suit is a computer, which is supposed to monitor how well the suit is working. NASA is quite proud of it. In fact, though, it's very primitive compared to anything you're likely to be using; it has about 1K bytes of program ROM. Even a Timex has more memory and processing ability. Moreover, it isn't as if the environment is particularly harsh: after all, the astronaut has to endure it as well as the computer. Alas, as far as I can tell, NASA didn't bother with modular design, so that upgrading that computer is going to be hideously expensive.

NASA doesn't have the money, so the upgrade probably won't happen.

The micro revolution was originally driven by the need for on-board computers in missile and space-booster guidance systems; it's a darned shame that the suits are designed in a way that makes it tough to retrofit newer technology. With

How to make your Apple run 3½ times faster.

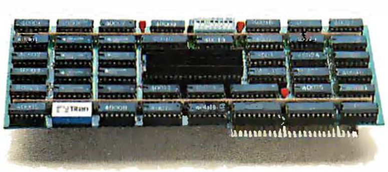


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proper design, the astronaut could have an in-suit computer that would not only monitor suit performance but also be a general-purpose computer and alarm clock. Instead, kids have better machines stored unused in their bedroom closet. Sigh.

Thanks for the Memory ...

One feature of the IBM PC is memory checking. For each block of eight memory chips in the PC, there's a ninth chip whose purpose is to store the parity bits for the other eight. A parity bit is the logical sum of the 1s and 0s in a memory cell; if there are an odd number of 1s in a "word" of memory, parity is odd; if an even number, it's even.

The IBM, along with many other PC-compatible machines like the Zenith Z-100, looks at the parity bit when it accesses a memory cell; if the parity isn't what it should have been, the PC reports a memory error.

It also dumps the program. Moreover, if there's any memory error on power-up, the IBM PC renders itself useless. This may not be optimum if the flaky memory chip is in an area your program won't be using.

The Eagle 1600 doesn't do parity checking, as I found out when I stuffed my Eagle full of memory chips. The Eagle has on-board sockets for 512K bytes of memory. This is eight blocks of 64K bytes, and thus I'd expected it to take eight additional memory chips for parity checking; but it didn't. The Eagle's chips are arranged in blocks of *eight*, not nine.

I was curious enough about this to ask the Eagle people, who referred me to Gary Kappenman, Eagle's vice-president for R&D.

Eagle had considered doing parity checking, he said; but it decided against it. First, parity checking introduces new chances for error. There are 12 percent more chips in the system, and each of those is as likely to fail as is any other memory chip; if it does, it will have the same effect as a real memory error.

Second, there's no software to take advantage of parity checking. The parity check doesn't *restore* your data; it merely notes that there's been some kind of error and dumps your program. Now if the error was in a program instruction, that's probably what you wanted; but if it were merely in a data area, so that the effect would be to spell the word "data" as "datq," I think I'd rather not be told if being informed dumps my text and renders my computer useless.

If there were software to tell you about memory errors and ask you what to do, Eagle might consider designing parity checks into its machine; until then, Eagle thinks it causes more problems than it's worth.

Incidentally, the Eagle 1600 has yet another undocumented feature, a memory test on power-up; one merely holds down the "t" key while the system comes up. Thus you can, if you like, test memory each time as the IBM does; but it's your choice. This will hopefully be documented in Eagle's revised systems manuals for the 1600. I wish the IBM PC offered a way of doing without the memory checks. It takes Lucy (for Lucy Van Pelt because she's a fussbudget) one

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whack of a long time to warm up and be useful now that we have big memory boards in her.

Don't Use Function 37

Time out for some technical advice to hackers and programmers. Others can listen in, but no apologies if you don't understand.

If you're writing software for CP/M 2.2x systems and you use BDOS (basic disk operating system) calls, do *not* use Function 37, "Reset Drive." Tony has tried to use that "feature" in several programs, and each time he's got into terrible trouble. There's an unrecoverable and undocumented bug in CP/M 2.2; the result is that attempts to use Function 37 to tell the program you have changed disks can cause ungodly horrible results.

As an example, you can write garbage into the directory of a hard disk, losing all the programs on it. (This is one reason that we do not and will not have a hard disk on our experimental system: we test a lot of software from many sources, and some of that software tries to use Function 37. This would be a disaster for us.)

You can also with Function 37 dump the user's program and scramble up his disk directories. There is no foolproof way to get around the bugs in Function 37. Don't use it. Instead, use Function 13, "Reset System." That's more work, and takes longer, because 13 recomputes the bit maps for all the logical disk devices, then sets logical disk "A" as the logged-on disk; if you started with something else logged on, you'll have to write code to take care of that.

Tony says this may not be fixed in CP/M-86, so be very careful about using it there, too.

Incidentally, there's no mention of this bug in Andy Johnson-Laird's otherwise excellent *The Programmer's CP/M Handbook* (Osborne/McGraw-Hill), which I recommend to anyone trying to write programs involving the CP/M operating system.

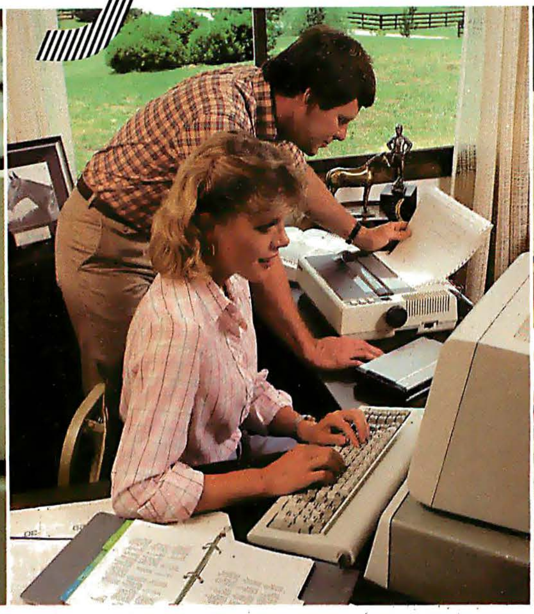
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I like the new IBM and Digital Research manuals. They're of a good size to fit onto bookshelves, and the box they come in is a good place-

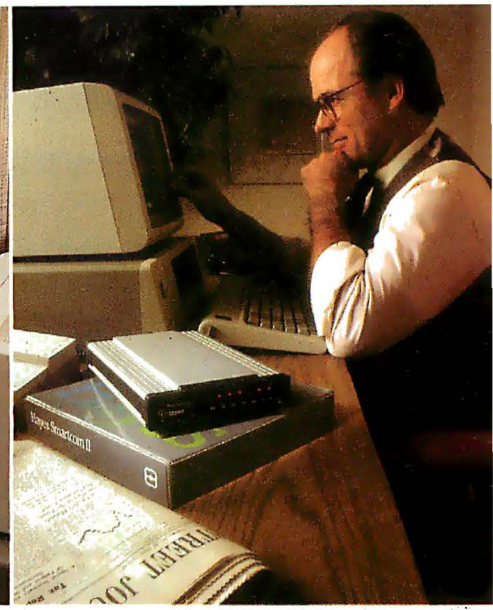
Hayes™ Your computer's telephone.



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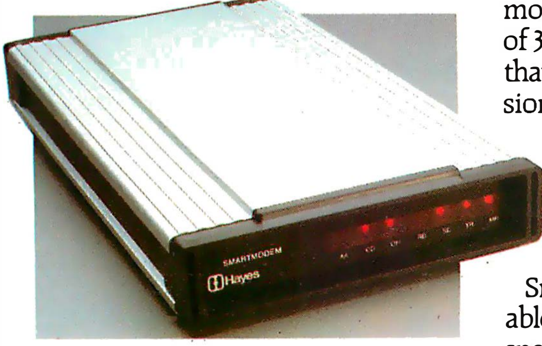
Gary: The pedigrees for next week's auction are as follows...



Sold 1000 shares at 33 for net profit of 6000. Richard.

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Both work with rotary dials, Touch-Tone® and key-set systems; connect to most time-sharing systems; and feature an audio speaker.

Smartmodem 1200B™ is also available as a plug-in board. Developed specifically for the PC, it comes packaged with Hayes' own communications software, Smartcom II.™

Smartcom II. We spent a lot of time developing it, so you can spend less time using it. Smartcom II prompts you in the simple steps required to create, send, receive, display, list, name and re-name files. It even receives data completely unattended—especially helpful when you're sending work from home to the office, or vice versa.

If you need it, there's always "help." This feature explains prompts, messages, etc. to make communicating extra easy.

With Smartcom II, it is. Case in point: Before you communicate with another system, you need to "set up" your computer to match the way the remote system transmits data. With Smartcom II, you do this only once. After that, parameters for 25 different remote systems are stored in a directory on Smartcom II.

Calling or answering a system listed in the directory requires just a few quick keystrokes.

You can store lengthy log-on sequences the same way. Press one key, and Smartcom II automatically connects you to a utility or information service.

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holder to remind you where to put the manual away when you're finished using it.

However, there's a problem. Much of Digital Research's software comes with a READ.ME file of errata and additions. It's formatted so that any simpleminded line printer can make a hard copy, and the line sizes are right for inserting the corrections into your document.

Alas, how do you do that? You need tractor-feed fanfold paper, and I've not found anyone who'll sell it in the proper size. The result is a long bout with scissors or paper cutter if you use formfeed, or standing there pretending to be a sheet-feeding machine if you use prepunched notebook paper (assuming you can find the proper size and hole arrangement of that).

Worry no more. William Simmonds of Anthropomorphic Systems has sent me a box of paper of proper size. He says, "I couldn't find anyone who made or carried this paper, so I simply had a large supply made up."

He'll sell you a carton of 1000 for $20 or a case of 2500 for $40. May be a stiff price, but he's not getting rich on it—and Lord knows it's a needed service.

Thanks, Mr. Simmonds.

One Way Out

Another public benefactor is Microsolutions and its Uniform program.

Regular readers will know that we've had our problems with disk formats. A few have written to ask why we don't use some kind of transfer program. The answer to that is simple: it's blooming slow. As a last resort we can always use serial transfer, but consider the situation where the machines are in locations separated by several miles, and both are in constant use. Much better to transfer disks. As my late mad friend MacLean used to say, "Parallel is faster than serial."

Microsolutions has a program called Uniform that reads many and many a 5¼-inch format; about 40 so far. There's also a MS-DOS/PC-DOS < -- > CP/M bidirectional file-copy program. The company's added the Epson QX-10 and is coming up with a version to run on the Otrona Attache.

If there's ever the slightest chance that you'll have to deal with several different kinds of micros, get Uniform; the savings in nervous energy and frustration are more than worth the price of the program. Microsolutions keeps revising it, too.

Strongly recommended.

Graphics and the Z-29

My son Alex is very interested in graphics, and I ought to have him work on this, but he's delivering the new WRITE manual to Compupro in Hayward. There's a story that goes with that, but this isn't the place to tell it.

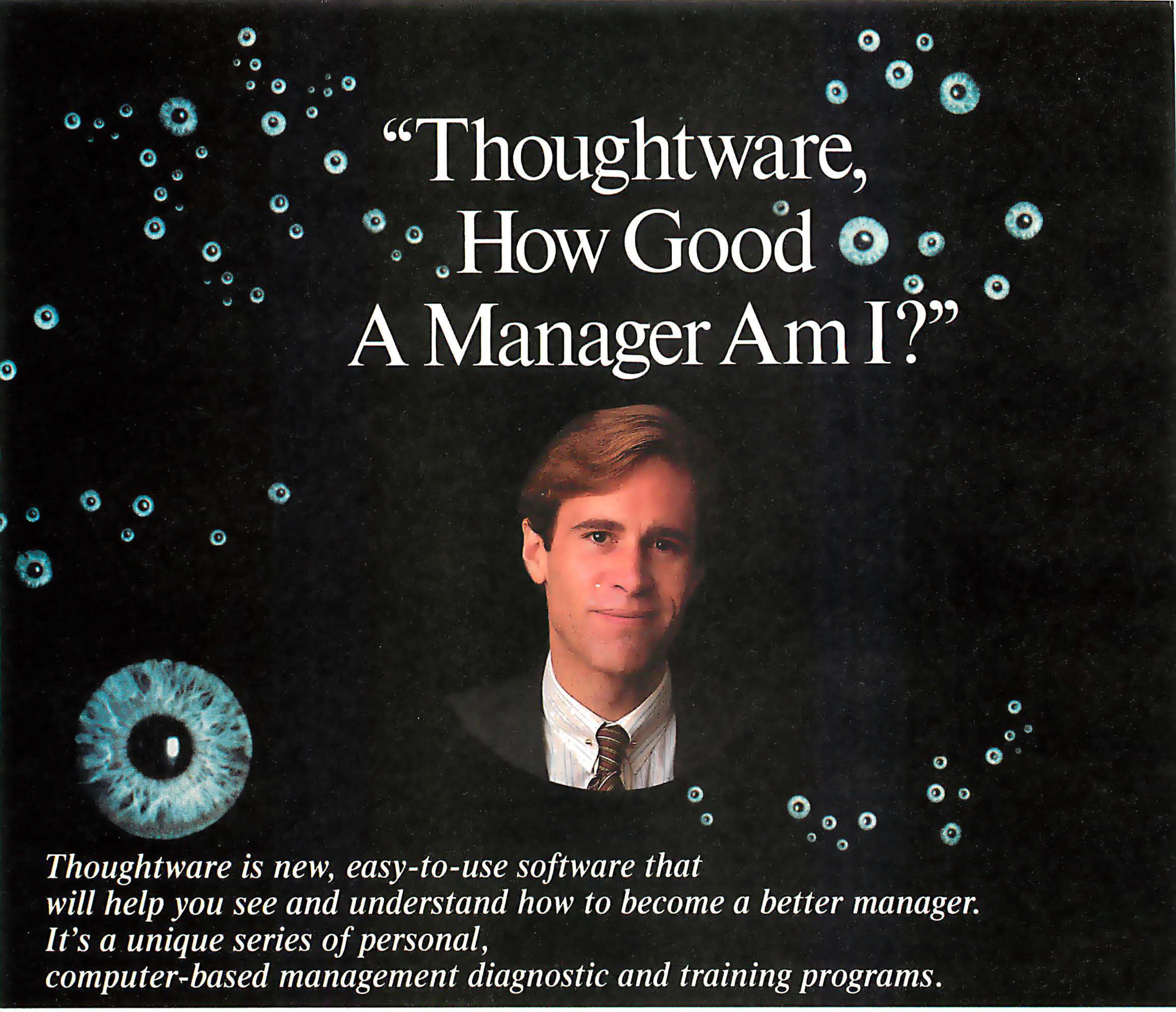
One graphics product that impressed him mightily was the Imaginator 2 from Cleveland Codonics. This is an add-on board for the Heath/Zenith Z-29 terminals; with that add-on, the Z-29 becomes one heck of a bargain graphics terminal. The monochrome add-on board is about $900, with 672 by 500 pixels (dots) shown on the screen.

The upgraded Z-29 keeps all its old features, and the graphics mode can be commanded either from the terminal keyboard or from the computer. The graphics mode emulates the popular Tektronix 4010/4014 terminal, with a number of additional commands that can be called in from BASIC or Pascal, etc. The Imaginator 2 uses the NEC 7220 graphics chip for some of its functions, but for speed reasons it doesn't rely on it alone.

There's also a color Imaginator that requires more modification to the Z-29.

The Imaginator 2 plus a Z-29 terminal costs less than many dedicated graphics terminals, and still it acts as a superb text terminal. Alex thinks Zenith ought to offer the terminal with this board in it and won't be surprised if it decides to do this.

Alex asked a lot of questions at COMDEX and is satisfied. (That's an understatement; he was impressed.) Still, fair warning: I haven't actually installed one of these boards in our Z-29, so I don't know how easy that is to do, or how good the documents are. Maybe in the future.



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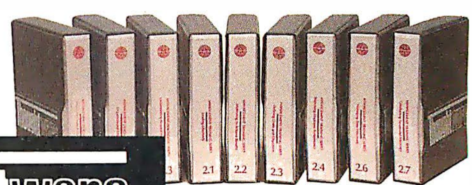
Unit 1 assesses your leadership style by examining the degree to which you are task- or people-oriented and how you use communication, teamwork, participation, initiative and support to get results. It also assesses your understanding of what motivates employees, promotes teamwork, and the extent to which you provide feedback.

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Zorro's Hidden Capabilities

Computer companies have a long tradition of hiding features of their new products. Zenith, for example, has yet to send me updates to its software to tell me how to format single-sided disks on Zorro the Z-100. It claims it will do that Real Soon Now. We'll see.

Zenith has also brought out CP/M-86 for the Z-100. It has been through beta testing and is out in the marketplace. We don't have our own copy yet, but Jim Ransom has had problems getting Logitech's Modula-2 compiler for CP/M-86 running with his Z-100. I don't know the details; perhaps when I get a copy of CP/M-86 here I can find out.

I find among my notes another: CP/M-85 cannot find a directory on the CP/M-86 disks that came from Logitech, but the IBM PC reads them fine under Concurrent CP/M-86. I suspect some format problems. More when I know more.

Meanwhile, there's a hidden feature to Zenith's CP/M-86: it can run CP/M-80 software without modification. Bringing up the Z-100 under CP/M-86 and then running normal CP/M-80 software with it gives you a much larger temporary program area (TPA: the "usable" memory for a program). At COMDEX Alex was unable to find any Zenith employees or dealers who knew about this feature. It ought to trumpet it, though, because it's an important selling point. Currently, DEC's Rainbow, the Compupro CP/M-8/16 systems, and the Fujitsu Micro 16 are the only machines I can think of that can do this.

With WRITE, for example, our text memory area is about 35K bytes under CP/M-85; but under CP/M-86 it's well over 40K bytes. WRITE works fine, and since Tony used some very complex BIOS (basic input/output system) calls in that program, it's a pretty good test.

Upgrading Zorro

Don't buy Zenith 8-inch drives. They're overpriced, and they don't work any better than anyone else's. Zenith's current software supports only two 5¼-inch and two 8-inch drives anyway, and it has no plans to upgrade to more. For that matter, there isn't enough power in the Z-100 case to run four full-power 5¼-inch drives anyway.

We've been using our Compupro 8-inch drives disconnected from the experimental box as a way to transfer files from the Zenith to our Compupro systems. Alas, for reasons I haven't had time to analyze, the only completely reliable way to do that is to use old-fashioned single-sided single-density IBM 3740/1-format disks. Sometimes the Z-100 will read double-density and sometimes it won't, and sometimes the Compupro doesn't seem to understand the Zenith's double-density disks. One day I'll do a systematic investigation; until then, we use Old Reliable slow 241K SSSD.

HELP!

I love to get mail. As I've said before, it's as if I have my own intelligence network out there; it makes writing this column no end easier, and obviously I can't do the User to User column at all without reader letters.

However.

Please help simplify my life. For example: there's no point in sending me long press releases about promotions within your company. Most of those are accompanied by photographs of nervous people with strange smiles. Sometimes we use the photos: we tack them to the walls with captions like "Hi! I'm not wearing any underwear!" or "I know a secret! I'm nude from the waist down!," which is what those grins suggest they're thinking.

We also use them as targets for our Beeman Hurricane air pistol. (I can recommend air pistol shooting at pictures of computer company presidents as a means for computer columnists to relax.)

Second, before you write asking me how to make contact with some company whose products I have reviewed, *please* look at the *big box* that *always* accompanies the column. If you read the October BYTE and want to make contact with Larry Weed's Problem-Knowledge Coupler company, look in the box in the Oc-

Items Reviewed

Concept $3995
Corvus Systems
2029 O'Toole Ave.
San Jose, CA 95131
(408) 946-7700

Concurrent CP/M-86 $350
Soft/Net Not yet released
Digital Research
POB 579
Pacific Grove, CA 93950
(408) 649-3896

DR Manual-Sized Paper 1000 sheets $20; 2500 sheets $40
Anthropomorphic Systems Ltd.
POB 819
Addison, IL 80101
(312) 629-5160

Eagle Spirit XL $4795
Eagle 1600 Series 1620 $4495; 1630 $6995; 1640 $8995
Eagle Computer
983 University Ave.
Los Gatos, CA 95030
(408) 395-5005

Imaginator 2 $895
Cleveland Codonics
18001 Englewood Dr.
Cleveland, OH 44130
(216) 243-1198

Rogue Not available
Artificial Intelligence Design Systems
POB 3685
Santa Clara, CA 95055

System Backup $49.95
Norell Data Systems
POB 70127
Los Angeles, CA 90010
(213) 257-2026

Uniform $49.95
Microsolutions
125 South Fourth St.
DeKalb, IL 60115
(815) 756-3421

Zenith Z-100 Computer $2899
Zenith Data Systems
1000 Milwaukee Ave.
Glenview, IL 60025
(312) 391-8865

tober issue rather than writing me to ask for the address.

Third, please do not send me form letters. If you're a dealer for products I've reviewed favorably, God bless you; but I don't need flyers describing stuff I've already written about, and I particularly don't need solicitations to buy a Sage computer. I already have one, for Heaven's sake!

Finally, there's a letter from Jonathan Sachs of Sand River Software to the managing editor of BYTE.

Sachs says, "Several weeks ago I wrote to Jerry Pournelle asking how I could get a copy of a program he mentioned. To date he has not replied."

Mr. Sachs says he is upset because "I pay money to read Jerry's column because I think I can profit from the information in it. Now it appears that he's got a program that would make my business more efficient—but I can't get it, or even find out for sure what it is, because he doesn't answer mail.

"From my point of view, this is no different from the behavior of a software producer that refuses to support the product it sells. Jerry regularly (and justifiably) rails against such practices. Does he realize he's guilty of them himself?"

Both the original letter inquiring about some of Tony Pietsch's experimental work and this letter to BYTE's managing editor were unaccompanied by a self-addressed stamped envelope.

I try to answer mail. I really do, and I apologize to all those whose letters I just can't get to; but darn it all, I don't like addressing envelopes and while I'm willing to pay postage if someone forgets, I don't like having it *demanded* of me.

No, Mr. Sachs; I do not believe a columnist has the same obligations to provide individual support as does a software company, nor do I believe BYTE's managing editor has the obligation to drop what he's doing and answer your letter. I'm sorry you're going to cancel your subscription, but I guess I'm just going to have to live with the situation.

In other words: I'll try to answer letters. I can't guarantee an individual reply even if you send a self-addressed stamped envelope, although I'll do my best. I certainly am not accepting heavy guilt trips because one or another letter didn't get answered.

I do feel pretty bad when someone sends me a really neat program and I don't get to it quickly.

I'm Really Trying . . .

As I write this, Dr. Allan Trimpi, who's *way* overqualified for the job, is off in the next room cataloging about seven cubic feet of software. We'll then assign the most promising stuff to assistants. Maybe we'll get caught up. It isn't likely, but we can try.

Micro land expands at a frantic pace. Trying to stay current can wear you to a frazzle. I love it.■

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE Publications, POB 372, Hancock, NH 03449. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply.

Jerry Pournelle is a former aerospace engineer and current science-fiction writer who loves to play with computers.

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Simple Menu Setup	Yes	No
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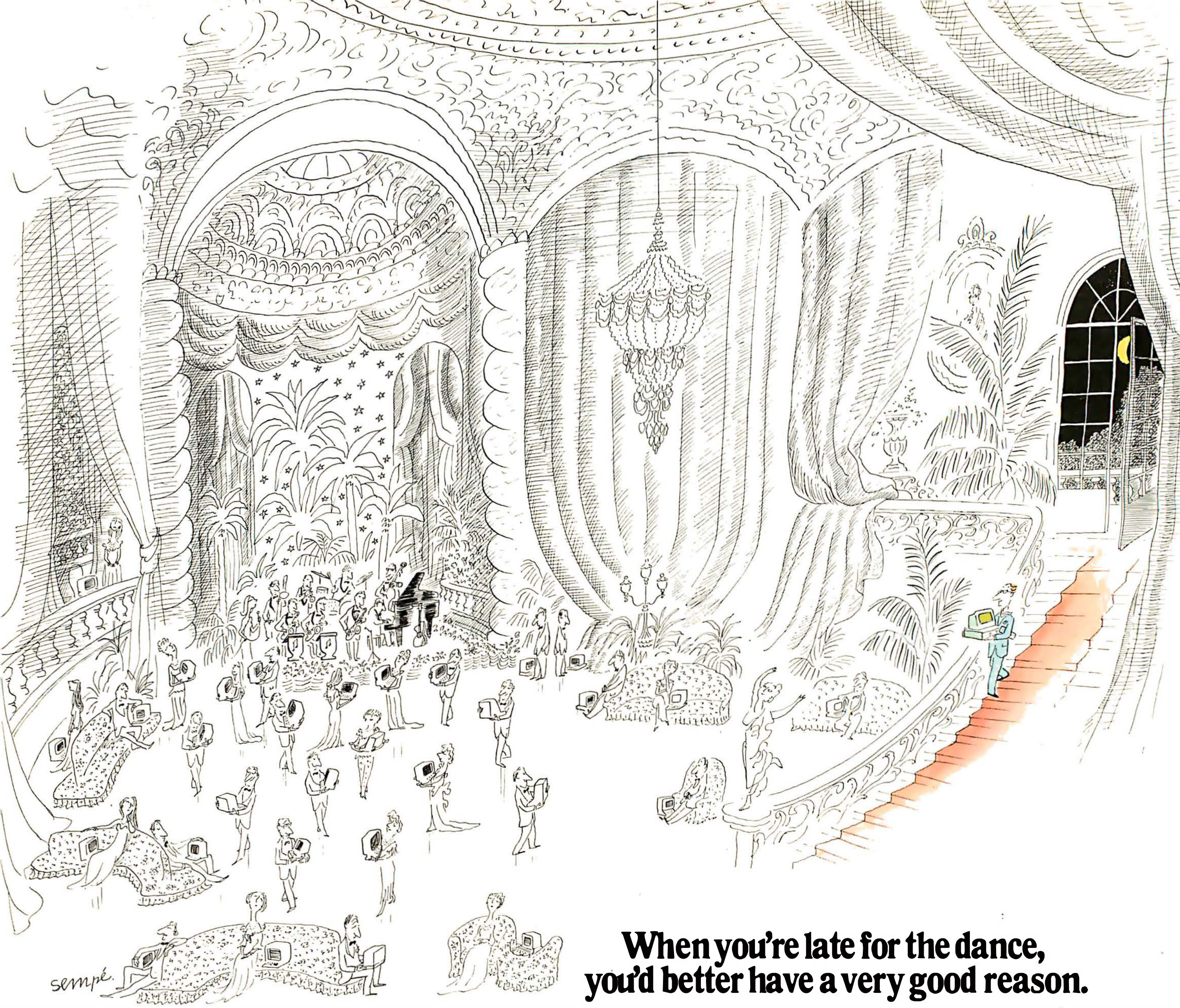
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The Sperry PC. What the personal computer should have been in the first place.

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A First Look at Dayflo

A free-form database gets you closer to your ideas

by Ezra Shapiro

Dayflo, a program announced at COMDEX in November and released during the first quarter of 1984, is representative of the new wave of "idea processing" software. Dubbed "a personal information-management system" by its creators, the program is a free-form, text-oriented database-management package, designed—at least initially—to run on the IBM PC XT.

The central principle behind the structure of Dayflo stems from the realization that note scrawling and the constant organization and reorganization of small scraps of paper into larger documents are a major part of what goes on in the world. A program that answers the demands of a typical office environment would have to be able to move quickly from one kind of note to another and allow for the impulsive entry or retrieval of information at the time of thought, without the traditional delays of program start-up and data entry.

Dayflo Software of Irvine, California, states that the average office personal computer is used only half an hour a day. Dayflo represents an attempt to create a flexible tool that can be used throughout the day. It allows variable-length text records to be tagged and recalled in much the same way that a standard database manager handles fixed-length records. However, Dayflo's form design is only as structured as the user wants it to be. The program seeks to accommodate itself to the ebb and flow of the workplace, hence its name and guiding philosophy. For a look at Dayflo in use, see the sequence of operations in photos 1 through 15.

The Metaphor

Dayflo is structured around the metaphor of the executive desktop—a fairly standard theme these days—but this version adds a number of perceptive twists. The program begins by assuming that you have an open file folder on your desk, one containing a collection of information that relates to your current project. Up to 19 other folders are piled off to one side, as if they had been gathered from a nearby filing cabinet. These folders may or may not pertain to the task at hand.

You're also equipped with a trash basket, a pair of scissors, a tray in which to drop pieces of paper, and a scratch pad, all of which are constantly available. During the course of the day, you pull the scraps in your folder into presentable form, sometimes using items from the other folders on the desk, sometimes digging new material out of the filing cabinet. If you're interrupted, simply jot a note on your pad—even if you happen to be in the middle of a paragraph. When the opportunity presents itself, you can make a copy of the note and file it in the appropriate location. When a task is completed, you close the folder and move on to the next, or you refile it in the filing cabinet and begin gathering material for the next job. At the end of the day, you can leave your folders as they are or stuff them back into the cabinet.

Dayflo adjusts to the ebb and flow of the workplace.

With a few additional permutations, this is Dayflo.

An Evolutionary Step

Text management has always been a primary concern of software developers. From the earliest line editors to the sophisticated screen-oriented word-processing systems of today, programmers have struggled to accomplish two goals: to apply the power of the computer to the relatively straightforward tasks involved in word-by-word data entry; and to aid the writer by easing the creative process of transferring ideas to paper. While the first goal has largely been met, the second has proved more elusive.

For obvious reasons, the focus in the computer industry has been on tailoring features to the needs of the business world. The first true word processors were aimed at the secretarial arena—a major selling point was (and still is, in many cases) not how much easier a program could make the process of creating a rough draft, but how much easier it could make the final presentation of an error-free business letter.

Recent efforts have concentrated on a more advanced problem, the business report. Spreadsheet-based text processors are good examples of the current approach, as are many of the integrated business packages now appearing on the market—programs that incorporate ledger computation, graphics, and data retrieval with text handling. But until the past year or so, very little has been done to expedite the storage, retrieval, and manipulation of *ideas* as opposed to data.

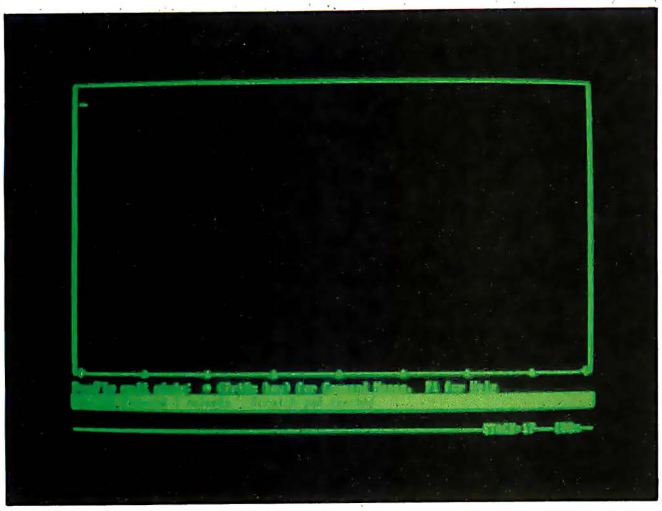


Photo 1: *Dayflo's basic entry mode, the "wait state." Text is entered and forms are designed much as they are with any word-processing program. Just press the F1 function key for a screen full of guidance.*

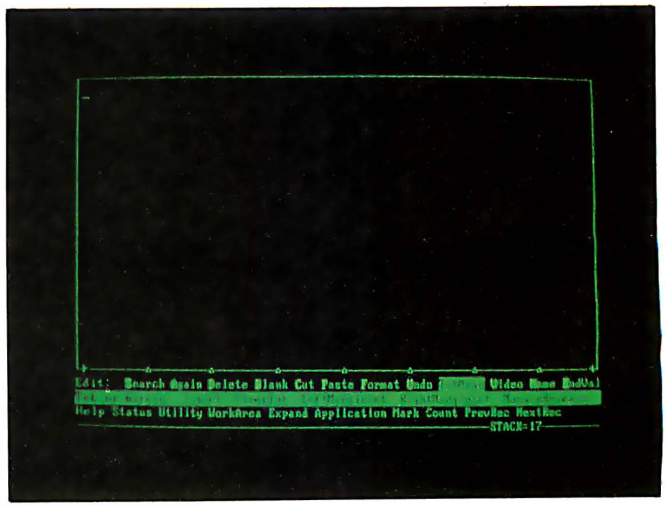


Photo 2: *A touch of the *(PrtSc) key puts you in command mode. Single-key choices let you select from a menu of word-processing options; moving the cursor to the bottom line gives access to overall Dayflo instructions.*



Photo 5: *The Status command provides a means to check the configuration of any aspect of Dayflo, and it's a good way to keep track of what you're doing.*



Photo 6: *The Work Area Status screen—a map of the Dayflo desktop. Only one record has been entered in the first stack; although some of the other stacks have been named, they're empty until records are either created or pulled from the main database.*

Most word-processing programs provide relatively simple block moves; they transfer chunks of text within an individual document or among a small group of documents stored in on-line buffers. When data transfers must occur *outside* the limits of a work in progress, things become unpleasant. The mechanisms provided by the typical text processor for, first, labeling and storing, and second, locating and recalling blocks of information, are cumbersome at best. In most cases, the writer must both name the block and remember the name in order to have a prayer of finding and reusing the information.

On the other hand, most database-management software, while adept at storage and retrieval of punch card-style chunks of data, is miserable at text processing, and the restrictions of fixed entry forms and precisely limited entry length would drive a creative writer up the walls. And it's almost impossible to combine a mixture of data types and formats into a cohesive whole without retreating to the use of a word processor.

Dayflo is a philosophical combination of text manager and database manager intended to provide the user with a quick method of linking labels to idea units, thus adding a degree of control and organization to a normally haphazard process.

How It Works

When you first enter the Dayflo environment, you are presented with an almost blank screen, representing the Dayflo "wait state." You can begin

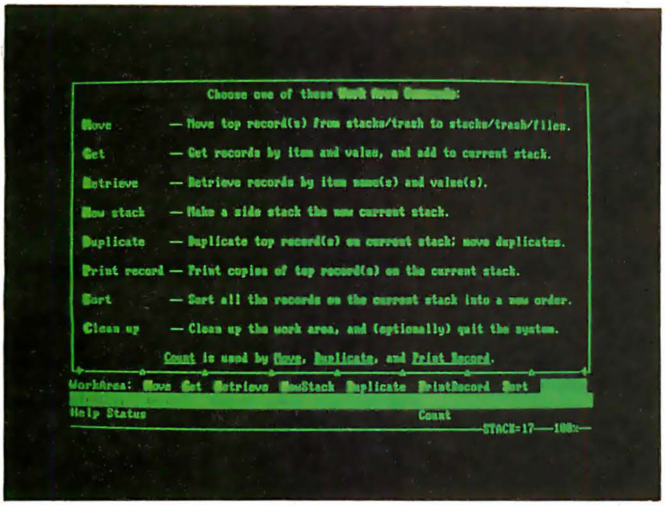


Photo 3: *The Work Area menu manipulates individual records and whole stacks; it's the route you take to move around on your "desktop." Once you tire of rereading the menu, commands can be activated by pressing a function key followed by a single letter.*

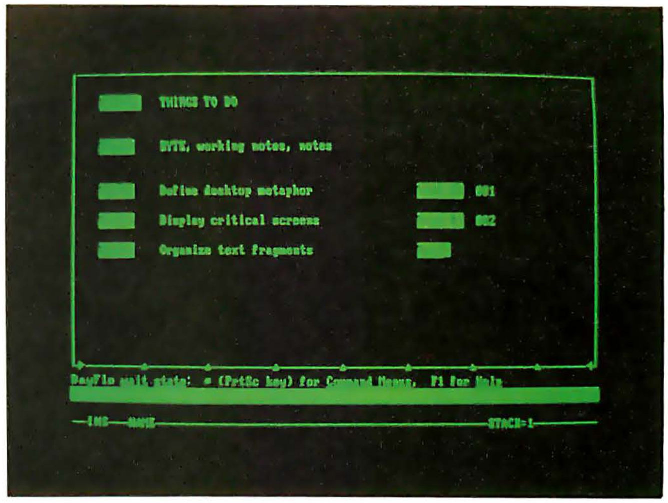


Photo 4: *A database-style form under construction. The INS and NAME flags appearing on the status line at the lower left of the screen indicate that you're in insert mode and that a field name is being entered. Once this record has been completed, it can be retrieved by searching for the contents of any single field name (or group of names).*



Photo 7: *The Profile Status screen shows how the system has been set to respond to errors and dangerous commands. You can change the response settings and some of the major video attributes.*

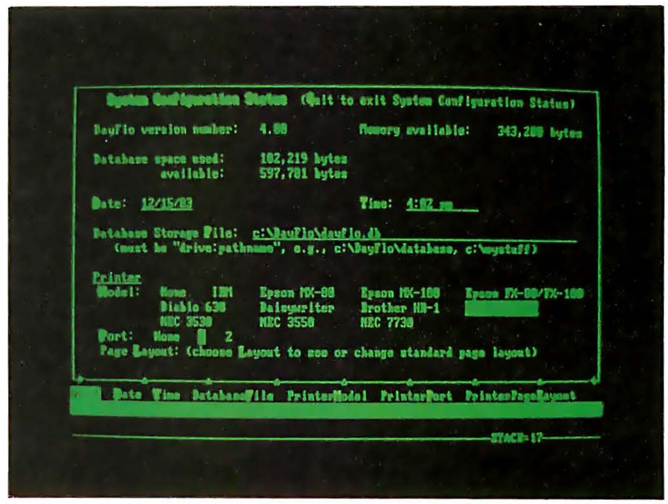


Photo 8: *The System Configuration Status screen allows changes to major system features. Dayflo can be used with more than one database—to switch to a different database, simply overtype the Database Storage File name with the new information.*

typing immediately, as the blank screen is essentially a word processor. You are working on the equivalent of a sheet of paper on a scratch pad resting in an open folder on your desk. (In Dayflo terminology, this "folder" is called a "stack," and that term will be used from here on.)

Pressing the *(PrtSc) key displays a line of menu options close to the bottom of the screen; these provide such standard functions as format changes, search and replace, block moves, and toggling between inserting and overwriting. A second list of menu choices, accessed by punching the down cursor key, shows the possibilities for accomplishing functions that deal with overall Dayflo operations.

The document you're creating is a single record in a text database. It and other records like it have been organized into 20 stacks. The current stack can contain a large number of records, which can be flipped through one by one. When you begin work in a new stack, the "bottom" of the stack is always the scratch-pad area, but as you flip through your records, you tuck them under the scratch pad; thus, while each stack contains a scratch pad, it won't always be the bottom record. A status line indicates your position in the stack as you move around.

Block moves of text can be performed by marking the beginning and the end of the section and pressing one of the PC's function keys. Selecting the "Cut" option moves the block into a buffer called the "cutout

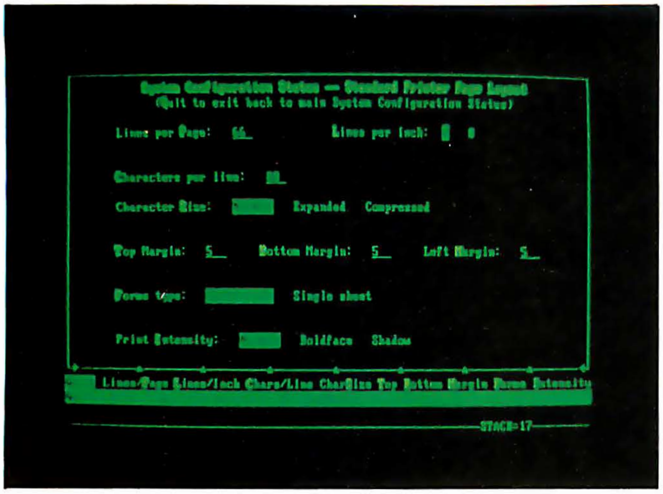


Photo 9: *Page layout options are limited but sufficiently complete to generate professional reports. More sophisticated layouts can be produced using Reportflo, an optional companion program.*

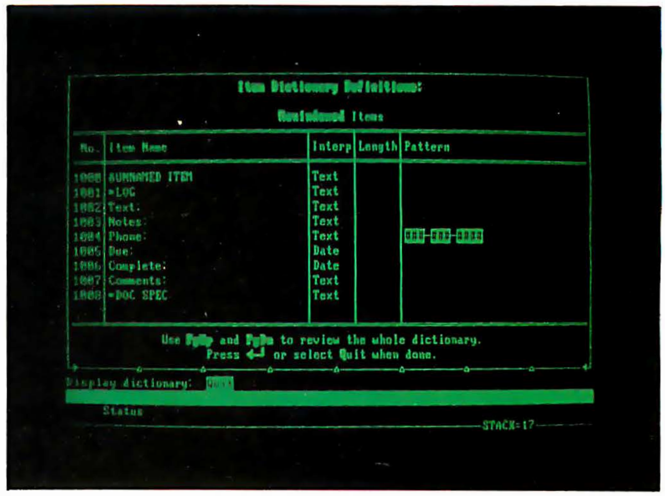


Photo 10: *The Item Dictionary lists all field names that Dayflo "knows" and their attributes. If you enter data that does not conform to the dictionary specifications, the program will request verification before accepting the information. Nonindexed items can be retrieved only as part of entire records; indexed items can be retrieved independently.*

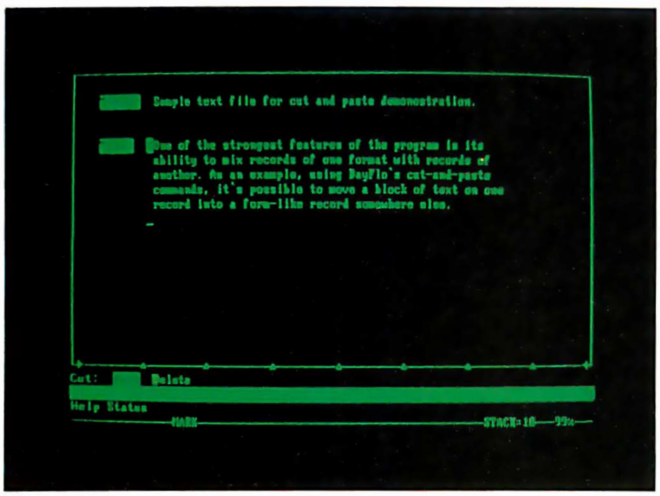


Photo 13: *Blocks are stored in the Dayflo "cutout holder" and pasted in where needed. Once a block has been placed in the holder, it remains available for reuse until an active decision is made to throw it away.*

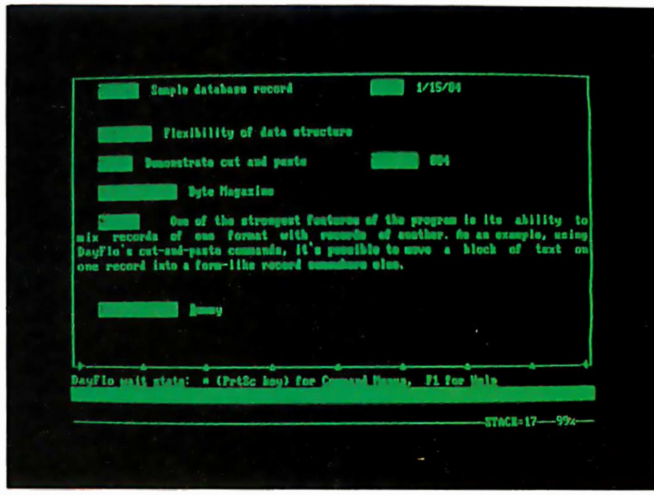


Photo 14: *The holder itself is much like a stack; blocks can be stored as if they were scraps of paper. The only real difference is that the cutout holder cannot be used to update the main database.*

holder." Positioning the cursor at the new location and choosing "Paste" completes the transfer. The holder itself is much like a stack, although the fragments it contains can neither be edited nor stored until reunited with actual stack records. It will accumulate snippets of text until it is told to clear itself, which is ideal for gathering a series of segments and then relocating them. Moves can be accomplished within a record or from one record to another, regardless of stack boundaries.

However, Dayflo is more than a text editor with advanced buffering capabilities: it is a full-fledged database manager. Once a record has been completed, it can be stored in a central database for future use. Although stacks can be created entirely from scratch, a more typical event would be to extract the contents of a stack from the database by searching for single or multiple relationships.

In a finished record, all entries must be tagged with a field name, or "item name," as defined in a user-generated name dictionary. A one- or two-keystroke toggle command activates the switch from text entry to name entry. "Indexed" names can be used for eventual retrieval of the item or its record; "nonindexed" names merely identify items and cannot be used as keys for searching.

Free-form blocks of text can be entered on the scratch pad or in the middle of a preexisting document, as with any simple word processor. However, Dayflo will not allow you to end an editing session until you have included at least one indexed field name (the default is "&RECORD NAME"). Such a precaution is designed to save the unwitting from themselves; if it were possible to store raw text in the main database

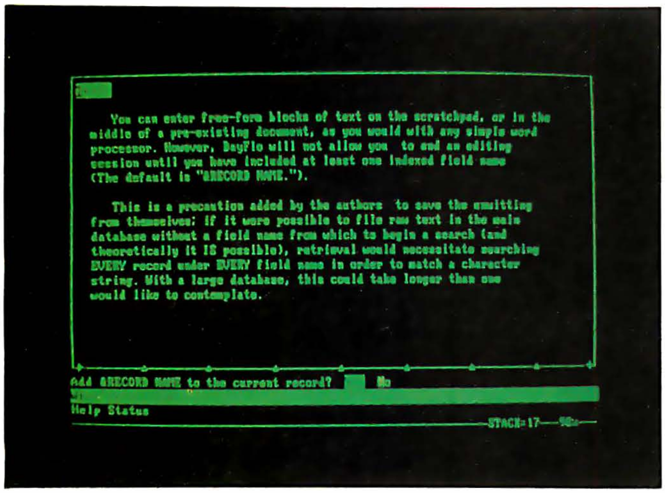


Photo 11: *Dayflo demands at least one indexed item name per record before it will allow the record to be saved. This is not a frivolous restriction.*

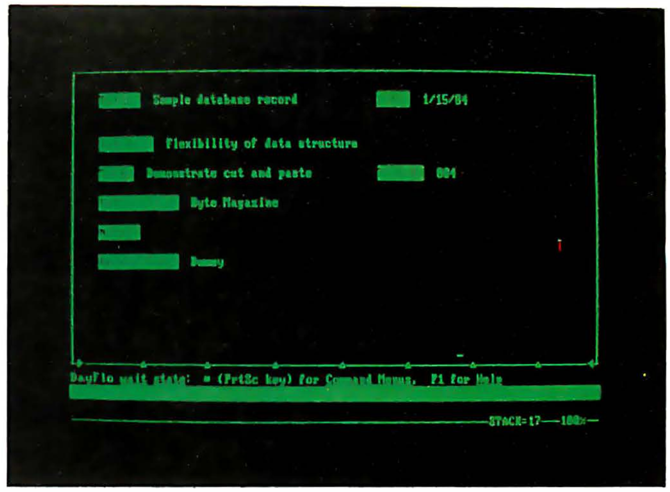


Photo 12: *Using Dayflo's Cut and Paste commands, a block of text can be moved from one record to another.*

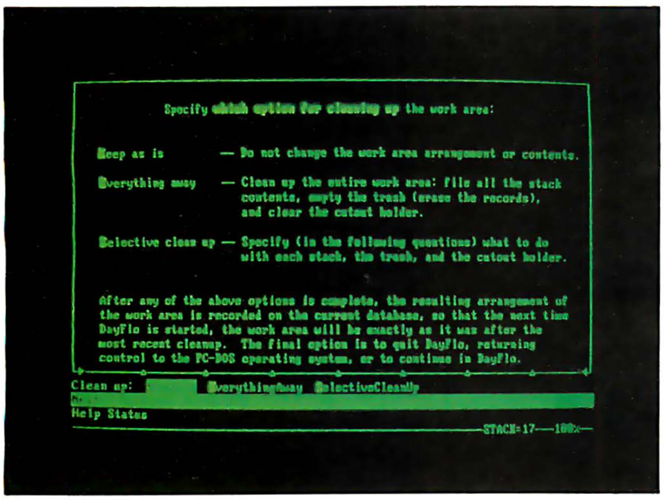


Photo 15: *Cleanup time. You can either leave your metaphorical desk as it is or put everything back in the main database. If you elect to refile materials, remember that you'll have to rebuild all your stacks when you begin working again.*

without a field name from which to begin a search (and theoretically it *is* possible), retrieval would necessitate searching *every* record under *every* field name in order to match a character string. With a large database, this could take a disturbingly long time.

Maneuvering on the Desktop

The Dayflo "Status" command provides access to a number of screens of configuration information that can be altered to suit the needs of the moment, including database in use, printer assignment, page layout, video attributes, warning messages, and text format. The most frequently consulted status screen is probably that for Work Area Status.

The Work Area is your desktop. The status screen shows the titles of all the stacks in use, the number of records in each stack, the number of records in the trash, the number of blocks in the cutout holder, the current stack, and your position within the current stack as measured in distance from the scratch pad.

Work Area commands let you build new stacks, move between stacks, print records, sort records within the stack, extract new records from the database, duplicate records, and initiate cleanup procedures. You can access command mode either by moving to the Work Area command menu and making your choice or by typing one function key followed by a mnemonic initial. In either case, maneuvers rarely require more than two or three keystrokes.

Weak Points

As is the case with all new programs, Dayflo is not without its weaknesses. To Dayflo Software's credit, however, it does not view the initial release as an end to the development process. Dayflo will be enhanced as the product evolves.

At the time this report was written, Dayflo had some drawbacks, particularly in the user-interface portions of the program. Shortly before its release to the buying public, Dayflo staff members were still debating whether the program should come up showing the Work Area Status screen (to provide an overview of work in progress) or return to the point at which the user had been working. The general opinion was that the latter solution would be best for users who had learned the system, and that opening with the status screen was an interim step in the training process that would prove annoying within several days of use.

However, as the prerelease versions lacked both provisions for field configurability and any sort of macro-key command capacity, either option would be irritating to a certain percentage of users. The problem was solved at Dayflo offices by the widespread use of Pro-Key, a keyboard reconfiguration program for the IBM PC—the solution is an admitted patch, well below the overall high standards of the operation.

A conscious effort has been made to imitate the Wordstar approach to menus and help screens (the experienced user can circumvent these screens with quick function-key commands), but a number of the screens could easily entrap and confuse a novice, and the language used, while concise, is intimidating. For example, the initial Dayflo work screen is labeled "wait state"—terse and to the point, but useless to the uninitiated.

Dayflo does not interact well with other software packages on the market. Although it can accommodate text output from other packages, Dayflo can't handle raw data files. The user must wait until the other packages spit out information in a form that Dayflo can digest. Although designers are working on a solution, it's not a simple problem; building in all the translation algorithms for the varied universe of available data structures is no small task.

Finally, Dayflo may suffer as a result of its massive size. The basic program is more than 75,000 lines of program code written in C, which compiles down to 1 megabyte. And that's without the object database or databases, Reportflo (a companion program for fancier output), or spreadsheeting capabilities (one of the first of a projected series of enhancement packages). To say that Dayflo is designed for a hard-disk environment is something of an understatement; it absolutely requires a hard disk.

Conclusions

The more you work with Dayflo and become accustomed to its idiosyncrasies, the more you become conscious of its power. It is possible to design simulated fixed-length

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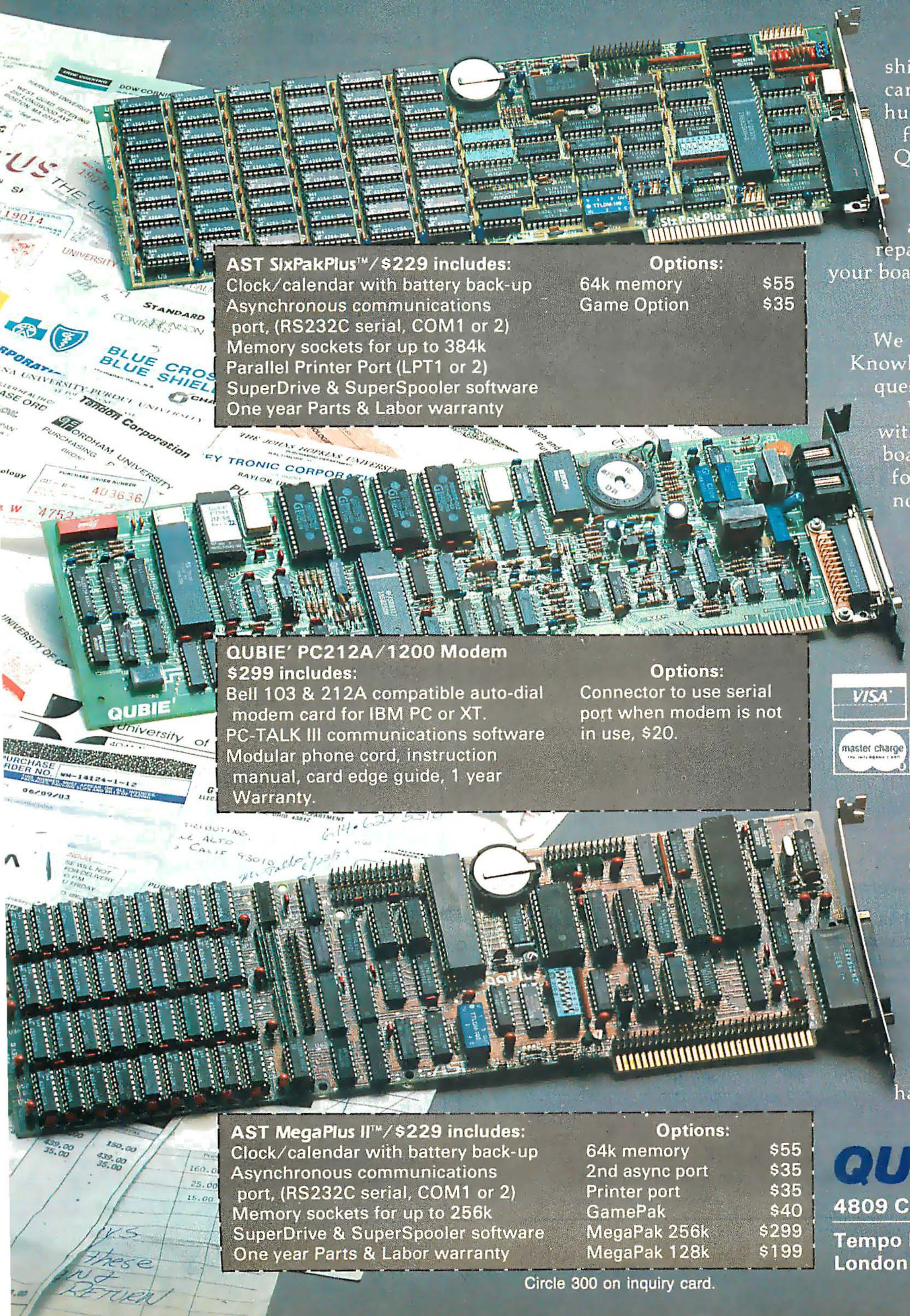
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databases (e.g., phone directories) that coexist quite peacefully with pure text records within the context of the overall structure of the program. Diverse records can be combined within the same stack or the same record, and data can be transferred between them at will. Command logs can be constructed to perform extremely complex search and retrieval operations; records can be copied, split, combined, and mutilated, as freely as you please, as long as you remember to include at least one indexed field name within a given record. True, the package demands a bit of learning, but its flexibility more than compensates for the effort.

Dayflo demonstrates the advantages of applying lateral thinking to an old problem. Its architects claim that the theory behind Dayflo is nothing revolutionary, but the program allows text entry with an uncommon ease and spontaneity. With a little practice, users find Dayflo procedures quite natural, and a return to older programs can be frustrating.

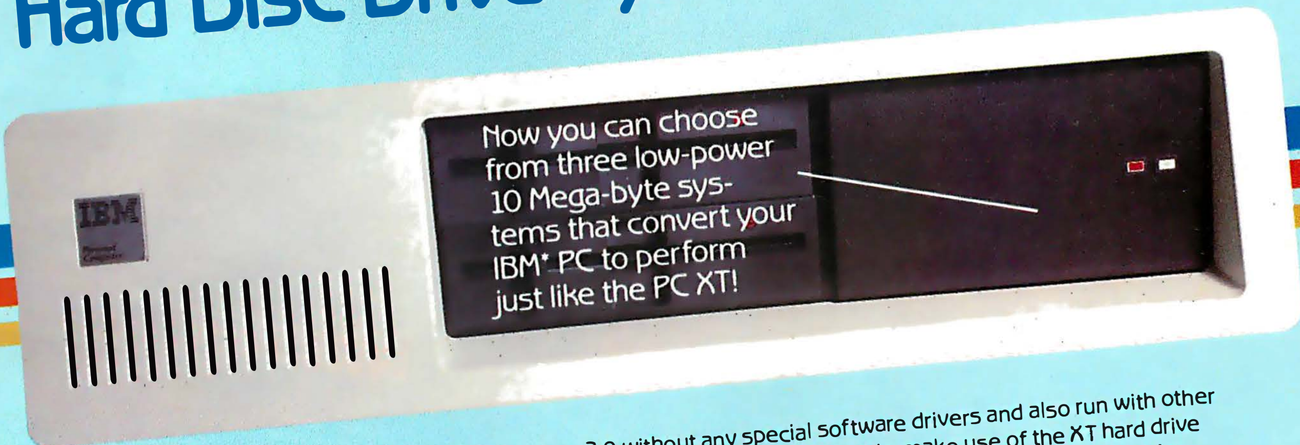
Dayflo's open logic *can* encourage you to develop a terrible mess, certainly as bad as any on a real desktop, and unless you perform regular cleanup, order in the stacks can fall apart. But, all things considered, it's pleasant to have that much control. Freedom is not without its price.

Whether or not Dayflo will dramatically increase the use of personal computers in the office is another question entirely. It's certainly a wonderful program for writers of all types, and executives who are used to working with software will be pleased by the speed with which they can pirouette through all that data. For them, the program is a major step in the right direction. But new users will have to be induced to learn the program before they can appreciate it. It may well be that Dayflo's shot at revolutionizing the workplace will depend more on marketing and training than on its outstanding potential as a tool. ■

Ezra Shapiro is a technical editor at BYTE's West Coast bureau. He can be reached at McGraw-Hill, 425 Battery St., San Francisco, CA 94111.

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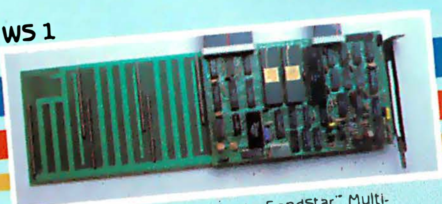


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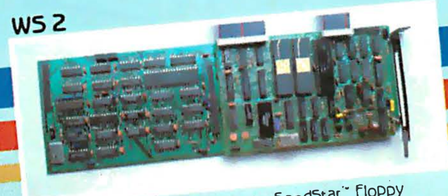
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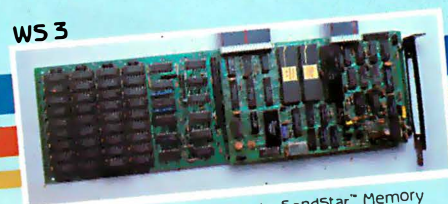
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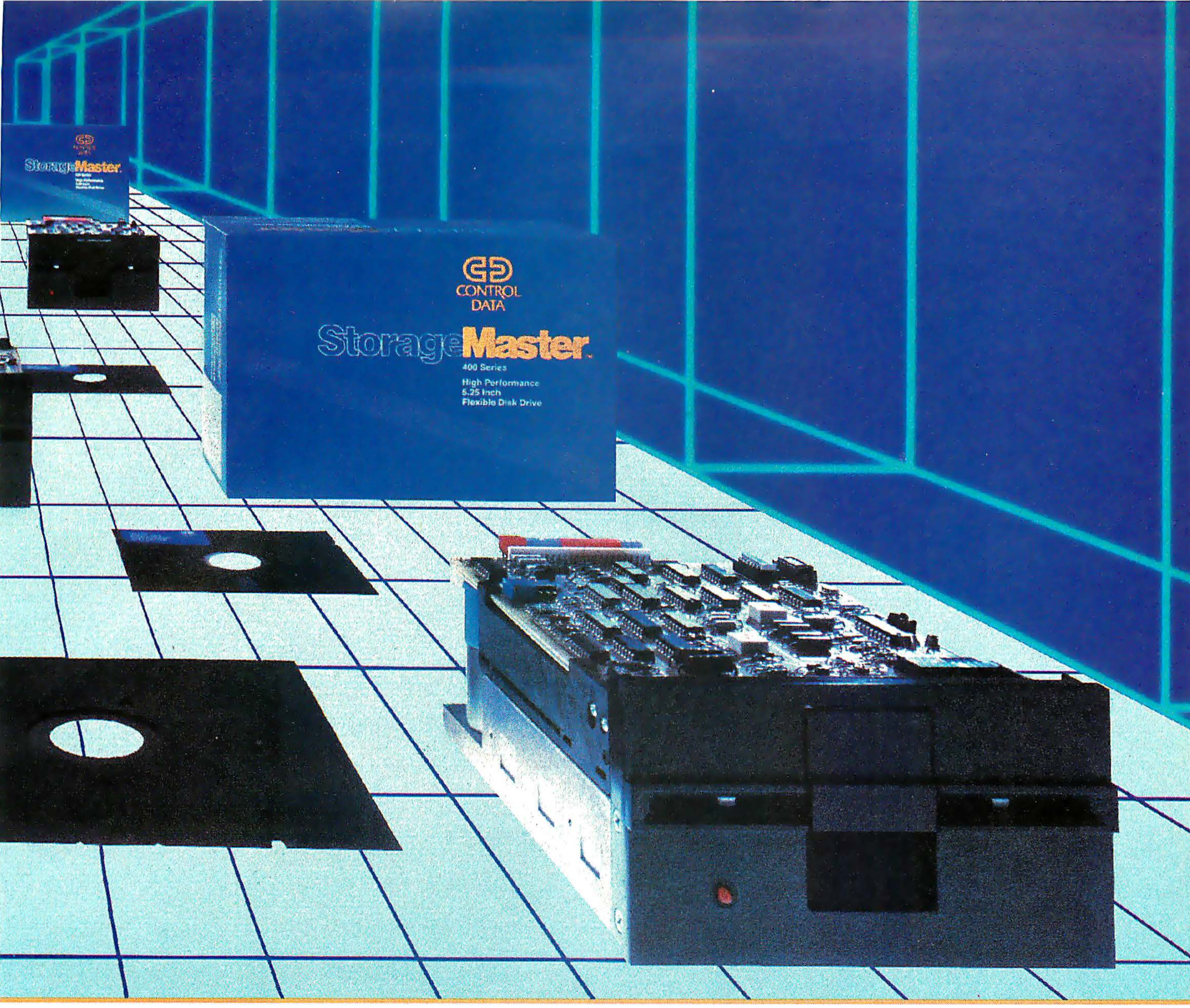
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Feigning Reality

The term *simulation* is suspect at best. In the minds of many, this word connotes a *counterfeit* or *sham:* a rhinestone masquerading as a diamond. In the context of computers, however, simulation has no negative meanings and we hope that our March theme issue helps this beleaguered word to regain its standing in the lexical community.

Simulation is the process of representing or modeling the behaviors of a system on a computer. This software model attempts to mimic the processes of the original system as nearly as possible. Data enters the model, is acted upon, and then the "system's" responses are recorded. Until quite recently, the field of computer simulation was exclusively the province of mainframe systems, but as microcomputers have become more powerful and capable, they have become increasingly important to the would-be simulationist.

Our lead article by Richard Bronson is an overview of microcomputer simulation; it covers the two basic types of computer simulation and surveys some of the simulation languages available for microcomputers. Articles by E. Hart Rasmussen and Pat Macaluso investigate the mathematical underpinnings of simulations. These articles contain source-code listings so that interested readers can try their hand at modeling.

In terms of applications, we explore computer-generated graphics with Peter Sørensen—simulations of things that never were. Philip Schrodt takes a look at using microcomputer simulations in the social sciences. Ronald Miller gives us a view of simulation and graphics on microcomputers. To round out the issue, Charles Pratt of the Society for Computer Simulation offers us a "going further" article for those who want to get more information about the field.

Even three of our software reviews are related to the theme of simulation and modeling. Stan Miastkowski checks out the Microsoft Flight Simulator for airworthiness on page 224, Dennis Barker reviews a mystery adventure game (page 301), and on page 274 Richard Grehan explores a software package that makes a computer simulate the internal workings of a computer—a novel twist indeed.

To discover some of the whys and hows of microcomputer simulation, please join us . . . in the queue.

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Computer Simulation

What It Is and How It's Done

An introduction to modeling and computer simulation as they apply to microcomputers

by Richard Bronson

According to Robert Shannon in *Systems Simulation: The Art and Science,* "Simulation is the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behavior of the system or of evaluating various strategies for the operation of the system." This description emphasizes both facets of an exciting and expanding field. The *art* is the creative process of constructing a simple model that adequately replicates the dynamic behavior of a system; the *science* involves transferring a model into computer code and then analyzing its behavior to predict the responses of a real system.

Computer simulation is a child of the computer age. Without computers there could be no computer simulation, and without computer simulation we would be without one of our most powerful and versatile methods for problem solving. Simulation techniques are currently used in over 70 fields spanning ambulance dispatching, consumer-behavior patterning, financial forecasting, harbor design, manpower planning, water-resource management, educational funding, aircraft design, and urban development. In each, simulation is a tool for solving problems.

Simulation is a unique discipline in that there are relatively few people engaged in the "pure science" aspects of the field; those who are develop simulation languages and statistical tests. The bulk of practitioners apply simulation to problem analysis and solution in other fields. They use simulation techniques to provide structure and definition to imprecisely worded verbal descriptions, to identify key components, to quantify interactions, and then to code, experiment, and recommend.

Two Types of Simulation

Simulation, as practiced today, falls into one of two types: discrete or continuous. Each has its own set of procedures for model conceptualization, each is based on a different area of mathematics, each uses its own set of computer languages, and each solves different sets of problems.

Discrete simulation deals primarily with queuing systems in which customers arrive at a service facility, then wait in a line (queue) if all servers are busy, eventually receive service, and finally depart from the facility when service is completed. Air traffic control problems are often embedded in such systems. Here, the aircraft seeking permission to land becomes the customers and the runway assumes the role of servers. With scheduling problems involving court cases in the judicial system, judges are modeled as servers, and the cases become customers.

Of prime interest in all queuing systems is the expeditious processing of customers. Since customer arrival times and the times required to service individual customers are generally random events, mathematical models for queuing systems are anchored in probability and statistics. Questions regarding the average time a customer spends in the system and the length of a queue can be answered only when the probability distributions governing arrival and service patterns are known (or can be assumed). For almost all probability distributions, the *only* technique available for answering these questions is computer simulation.

Large blocks of time in which the state of the underlying system does not change are a defining characteristic of discrete simulation. Another characteristic is that units moving through the system are measured as integers. Queuing systems have these properties, which is why their problems are so amenable to solution by discrete simulation. Customer arrivals and customer departures occur in unit amounts; the number of customers in a service facility at all times can be represented as an integer. Arrivals and departures occur at discrete instances and, in between, nothing of importance to the state of the system transpires—the same customers receive service and the same customers wait.

Continuous simulation, in contrast, deals with systems that change continuously with respect to time and with measurements that are not re-

stricted to integers. A simple example is the trajectory of a rocket in flight; there is no instant of time when the system as measured by the rocket's position in space does not change. Less obvious examples are provided by Levin and Roberts in their book *The Dynamics of Human Service Delivery* (see bibliography). For example, one case study assesses the effects on student performance from student-teacher interaction at the elementary school level.

Of prime interest in all continuous systems is the time-varying behavior of all quantities in the system. Since behavior patterns are governed generally by rates of change, mathematical models for continuous systems are based on differential equations. And the *only* technique available for solving most sets of differential equations is numerical integration, which is the core of all continuous-simulation languages.

It's not always clear whether it is better to use discrete or continuous simulation in solving a particular problem. Population growth problems seem ideal candidates for discrete simulation. They can be modeled easily as self-service queuing systems with people as customers (and their own servers), births as customer arrivals, and deaths as customer departures. Yet population problems often are analyzed with continuous simulation primarily because the time between successive births and deaths is small (seconds) compared to the time span of interest (years). It is more economical in both computational time and memory requirements to approximate the system as a continuous one rather than having the computer update its queue files every few seconds. The problem of using nonintegral values is obviated by the magnitude of the items being measured; a population of 60.38 is perfectly acceptable when the unit of measure is millions of people.

The choice between simulation branches is further obscured by systems that possess both types of behavior. Pritsker and Pegden offer a good example in their book *Introduction to Simulation and SLAM* (see bibliography) of such a hybrid system, part continuous and part discrete, based on a simulation study by Ashour and Bindingnavle. Ingots of warm steel arrive at a soaking pit of hot liquid where they are immersed and heated to high temperatures for further processing. If the soaking pit is full, ingots must wait for space in a holding tank. The random arrival pattern and subsequent queuing are vintage discrete simulation. The service pattern, raising the temperature of the ingots as they soak in the hot bath, is continuous based on the temperature of the pit, the temperature of the arriving ingots, and Newton's law of heating. To simulate such a system, elements of both types of simulation are needed.

Models

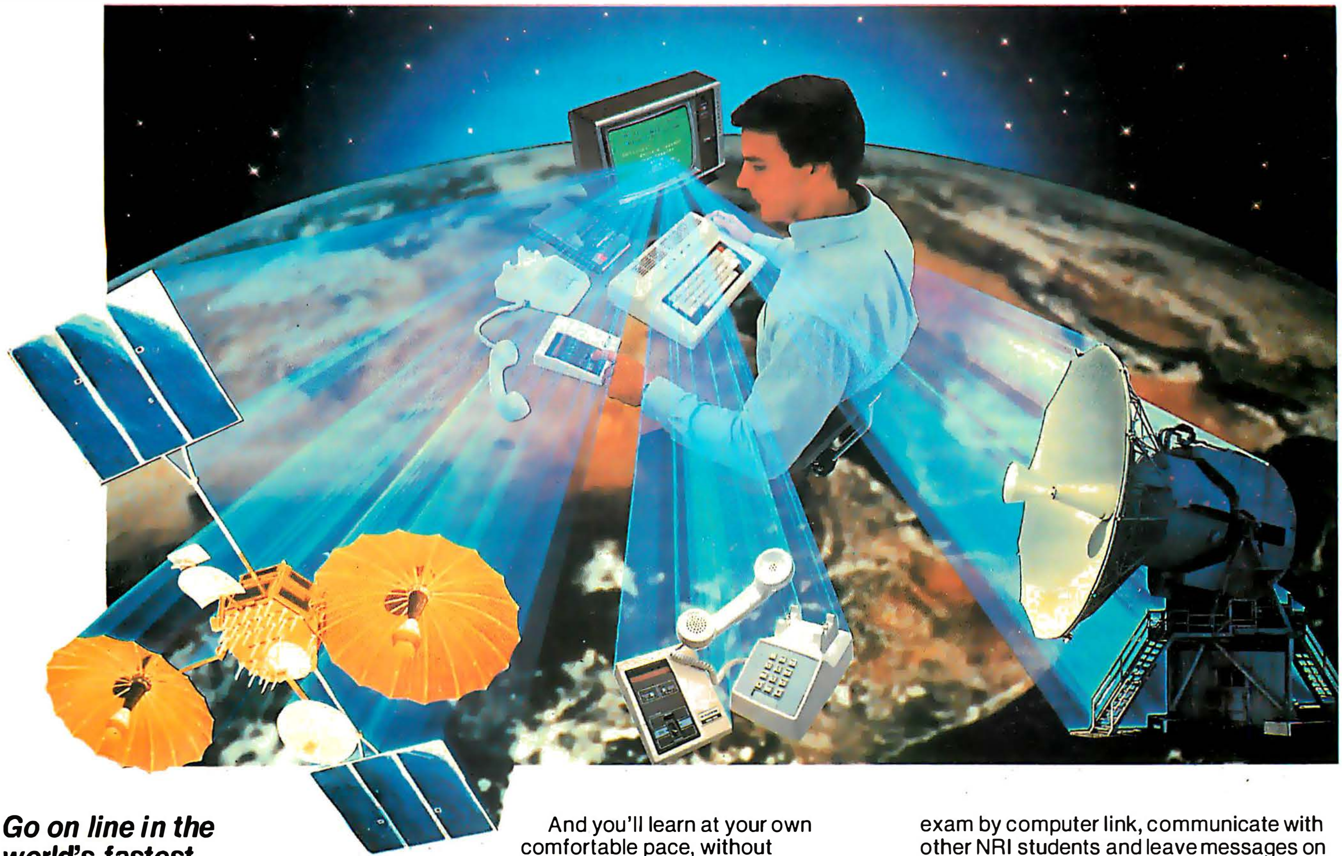
Models are often classified as either *iconic, analog,* or *abstract.* An iconic model looks identical to the system it represents; one example is a wood and paint mock-up of an automobile shell. From a distance the mock-up appears to be an automobile, but since it contains no engine or interior, it is an incomplete one. Nonetheless, if the purpose of the model is to determine the aerodynamic characteristics of the car it represents, then it may be all that is needed to achieve the objective. An analog model acts like the system it represents even though it may appear quite different. Engineers often build electrical systems to model mechanical spring systems and then predict the motion of the mass at the end of the spring by measuring the current in the electrical model. Abstract models are sets of mathematical equations for quantities in the systems being modeled. The solutions of the equations are used to predict the behavior of the systems.

Discrete simulations employ analog models with computer files representing most components in a system. Each customer is a file, every queue is a file, and there is even a calendar file for storing service completion times and arrival times. These files are then manipulated according to patterns established by the modeler to mimic the behavior of the underlying system. Only servers are spared the indignity of being reduced to files; instead they become variables assigned either the value 1 when they are busy, or the value 0 when they are free.

Abstract models of differential equations are the bases of all continuous simulations. For technological systems, such equations are consequences of physical principles, such as Newton's laws of motion, governing changes in the states of the systems. Unfortunately, no such principles currently exist in the social sciences, but in the late 1950s and early 1960s Jay Forrester and his associates at MIT developed system dynamics as an approach for generating differential equations in these areas. Prior to 1960, continuous simulation was practiced almost exclusively by electrical and aerospace engineers. As a result of Forrester's work, abstract models now exist in economics, sociology, management science, and ecology.

Once constructed, nearly all simulation models must be coded for a computer and then run before any inferences are possible. Mathematical solutions are preferred but almost never obtainable, given the complexity of interactions between components in models, even reasonably simple models. Mental inferences are dangerous. Forrester, in a 1971 article for *Technology Review* (see bibliography), cited the following experience:

> Time after time we have gone into a corporation that is having severe and well-known difficulties. The difficulties can be major and obvious, such as a falling market share, low profitability, or instability of employment. Such difficulties are known throughout the company and by anyone outside who reads the management press. One can enter such a company and discuss with people in key decision points what they are doing to solve the problem.... In a troubled company, people are usually trying in good conscience and to the best of their abilities to solve the major difficulties. Policies are being followed at various points in the organization on the presumption that they will alleviate the difficulties. One can combine these



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> policies into a computer model to show the consequences of how the policies interact with one another. In many instances it then emerges that the known policies describe a system that actually causes the troubles. In other words, the known and intended practices of the organization are fully sufficient to create the difficulty, regardless of what happens outside the company or in the marketplace.

In Forrester's experience, individuals perceive a problem, develop a conceptual model of the system in which the problem exists, mentally run the model, and develop strategies for alleviating the problem based on these runs. The net result is often the opposite of that intended because the mental inferences were faulty.

Lave and March, in their book *An Introduction to Models in the Social Sciences* (see bibliography), present a more striking example of the pitfalls awaiting those who would bypass the computer in favor of mental deductions. The example is credited to Bertraud de Jouvenal and features the thoughts of the philosopher Jean Jacques Rousseau. Rousseau built a population model for eighteenth-century England based on three assumptions: (1) the birth rate in London is lower than the birth rate in rural England; (2) the death rate in London is higher than the death rate in rural England; (3) as England industrializes, people leave the countryside in increasing numbers and move to London. Rousseau concluded that, since London's birth rate was lower and its death rate higher than rural England and since people moved from rural England to London, the population of England must decline eventually to zero. Had Rousseau coded his model for a computer he would have reached just the opposite conclusion. In quantifying the rates for computer input, he would have seen that as long as London's birth rate was greater than its death rate, regardless of how they compared to similar rates elsewhere, the population of London must grow.

If a scholar of Rousseau's stature can err on such a simple model, then Forrester's experiences with twentieth-century man and complex models are not surprising.

When a computer is used to run a model, a computer language is a necessity. Although some experienced practitioners prefer a general-purpose language such as FORTRAN, most opt for specially designed computer-simulation languages that also fall into two classes: discrete and continuous. Both types are easy to program and possess special features of value to simulationists. Both permit the modeler to focus attention on the system rather than the details of programming.

Discrete Simulation Languages

There are hosts of discrete simulation languages available: SIMPAS, CAPS, SIMULA, and DEMOS to name but a few, with new ones introduced yearly, but the overwhelming majority of simulation studies that utilize such languages are written in GPSS, SIMSCRIPT, GASP, or SLAM. GPSS was introduced first by IBM and its latest version, GPSS V, is still supported by them. A faster

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version, GPSS/H, which runs on a wider variety of mainframes and minicomputers, is supported by Wolverine Software of Annandale, Virginia. SIMSCRIPT is a product of CACI of Los Angeles, California, and requires its own compiler. Both GASP and SLAM are supported by Pritsker & Associates of West Lafayette, Indiana, and are compatible with many FORTRAN compilers.

SIMSCRIPT and GASP are event-oriented simulation languages, which means that they are a set of subroutines for file creation, file manipulation, scheduling, and statistical analysis that the modeler combines in the way that best replicates the system under study. A completely coded model consists essentially of calls to subroutines and assignment statements for updating files associated with individual customers.

GPSS is a process-oriented simulation language in which the modeler stipulates the processes involved in the system, such as creating customers, seizing servers, queuing in lines, and collecting statistics. Once this delineation is complete, the simulation language automatically creates, manipulates, and updates the necessary files. Process-oriented languages are conceptually easier to understand and easier to code than event-oriented languages, but the latter are more flexible and give modelers a wider range of options for representing systems.

SLAM is a relatively new language and potentially the most versatile of all. It allows for both event-oriented and process-oriented simulations as well as continuous simulation for those segments of a model requiring it. Figure 1 is the main portion of a SLAM program in its process-oriented mode for a one-person barber shop. The first and last lines simply frame the process being modeled. Line 2 creates customers with times between arrivals governed by an exponential distribution having mean 25. Line 3 directs each arriving customer into queue #1 to await the barber. Line 4 of the code states there is only one barber whose service times are normally distributed with a mean of 20 and a standard deviation of 5. This activity is designated as activity #1. Line 5 instructs SLAM to terminate a customer upon completion of service and to terminate the simulation after 100 customers have been processed. SLAM does the rest including taking the first customer in the queue and placing that person in service when the barber is free, reporting statistics on each queue and each activity designated by a number, and sampling from stipulated probability distributions. SLAM automatically creates and updates a calendar of service completion times for all customers in service coupled with the time of the next customer arrival, and at each time in chronological order, SLAM creates, manipulates, and terminates all necessary files for replicating the queuing system as stipulated in the code.

```
NETWORK;
  CREATE,EXPON(25);
  QUEUE(1);
  ACTIVITY/1,RNORM(20,5);
  TERMINATE,100;
  END;
```

Figure 1: *The main portion of a queuing-system simulation written in the language SLAM.*

```
 $D1
     BAL. = 0.05*BAL
 $M10
END
     BAL = 1000
     TMAX = 25
END
     LIST BAL
     PLOT BAL
END
```

Figure 2: *The main portion of a bank balance simulation written in the continuous-simulation language DARE.*

Continuous-Simulation Languages

All continuous-simulation languages are based on numerical-integration routines for solving sets of first-order differential equations, both linear and nonlinear. Many adhere to standards established by the Society for Computer Simulation (SCS) of La Jolla, California. Such languages provide modelers with a choice of integration algorithms including variable-step Runge-Kutte routines and routines for solving stiff differential equations, they allow inclusion of user-written subroutines in the host language of the source code, and they provide options for graphic output with internal scaling of axes. A continuous-simulation language can be mastered in under five hours.

The forerunner of most continuous-simulation languages is the IBM product CSMP, but there are now many others that run on a greater variety of computers. Some of these languages include CSSL-IV from Simulation Services of Chatsworth, California, ACSL from Mitchell and Gauthier Associates of Concord, Massachusetts, EASY5 from Boeing Computer Services of Tukwila, Washington, and DARE from the Department of Electrical Engineering at the University of Arizona.

Figure 2 is the main portion of a DARE program for solving a bank balance problem modeled by the differential equation:

$$dBAL/dt = 0.05BAL; \; BAL(0) = 1000$$

The code is separated into sections, each terminating with an END statement. First, derivatives are denoted by periods following variable labels. The first section headed by $D1 is the operational segment and contains all the differential equations in the model. It also includes the $Mnn line that instructs DARE as to which of ten different integration routines it should employ. The second section is the specification segment including both the initial conditions and TMAX, the length of time the simulation should run. The last section specifies output, LIST for a table, PLOT for a graph. DARE does the rest, including solving the differential equations (here there is only one), and providing appropriately scaled graphs for all output variables.

DYNAMO, supported by Pugh Roberts Inc. of Cambridge, Massachusetts, differs from other continuous-simulation languages in that it is designed expressly for social scientists using the system-dynamics approach to modeling. DYNAMO con-

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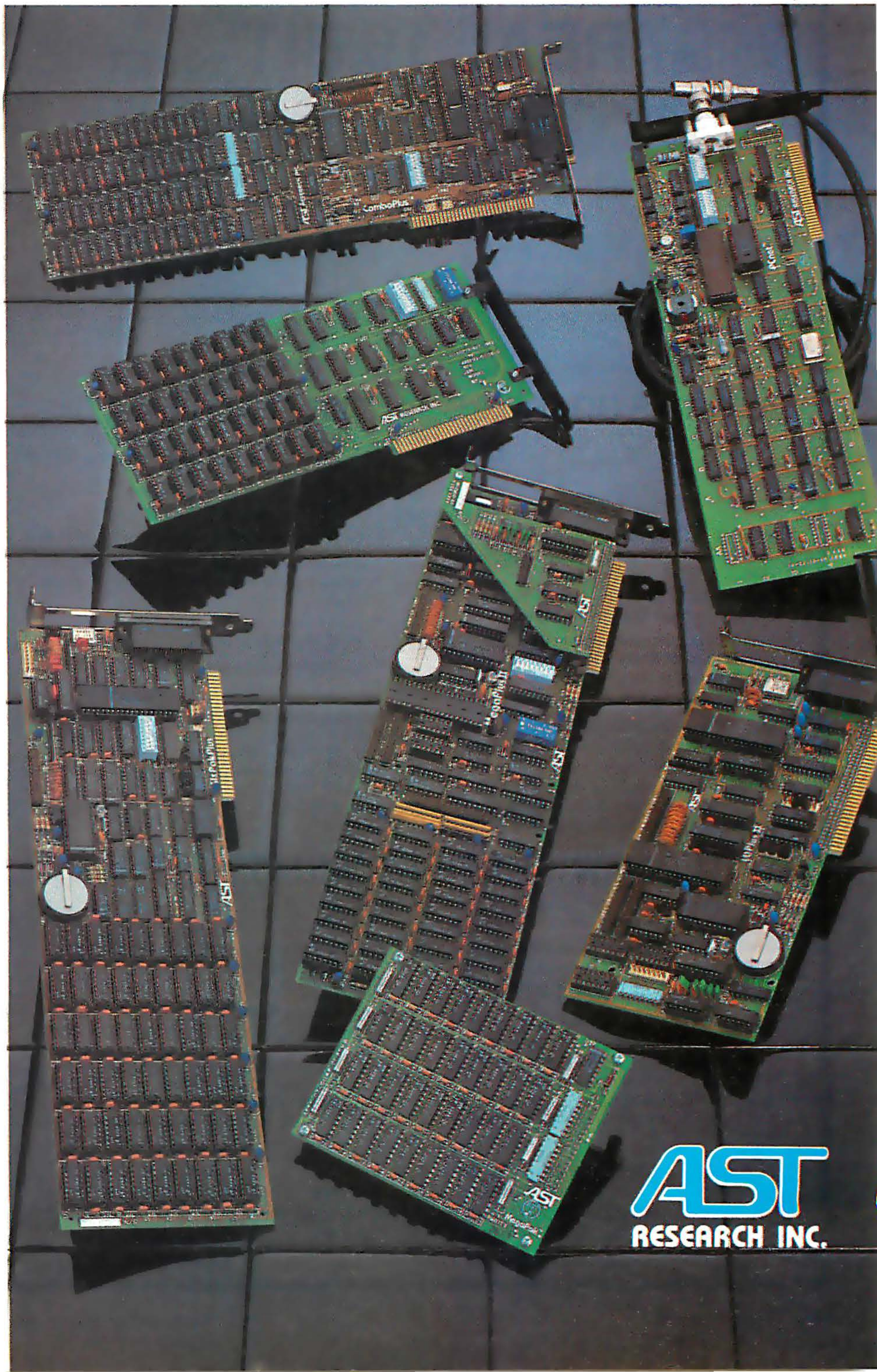
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tains simple integration algorithms rendering it unsuitable for engineering simulations and does not allow easy inclusion of user-written subroutines. Its main appeal is that modelers need not know calculus or differential equations to use the language. DYNAMO only requires modelers to code rates of change, and then it composes and solves the resulting differential equations internally. The language, therefore, is particularly attractive to modelers of social systems.

Simulation and the Personal Computer

The exciting news in computer simulation is the same story sweeping the entire computer world: microprocessors. Some languages are already available, including micro-DYNAMO for both the Apple II and the IBM PC from Addison-Wesley; SIMAN, a discrete-simulation language for the IBM PC from System Modeling Corporation of State College, Pennsylvania; MicroNET, a discrete-simulation language for a variety of personal computers from Pritsker & Associates; ACES, a continuous-simulation language for the Apple II from Modulo 2 Company of Tukwila, Washington; and SIMSCRIPT for the IBM PC, and many others are sure to follow. Conferences, such as the 1982 Modeling and Simulation on Microcomputers Conference (sponsored by SCS), have encouraged further participation. ■

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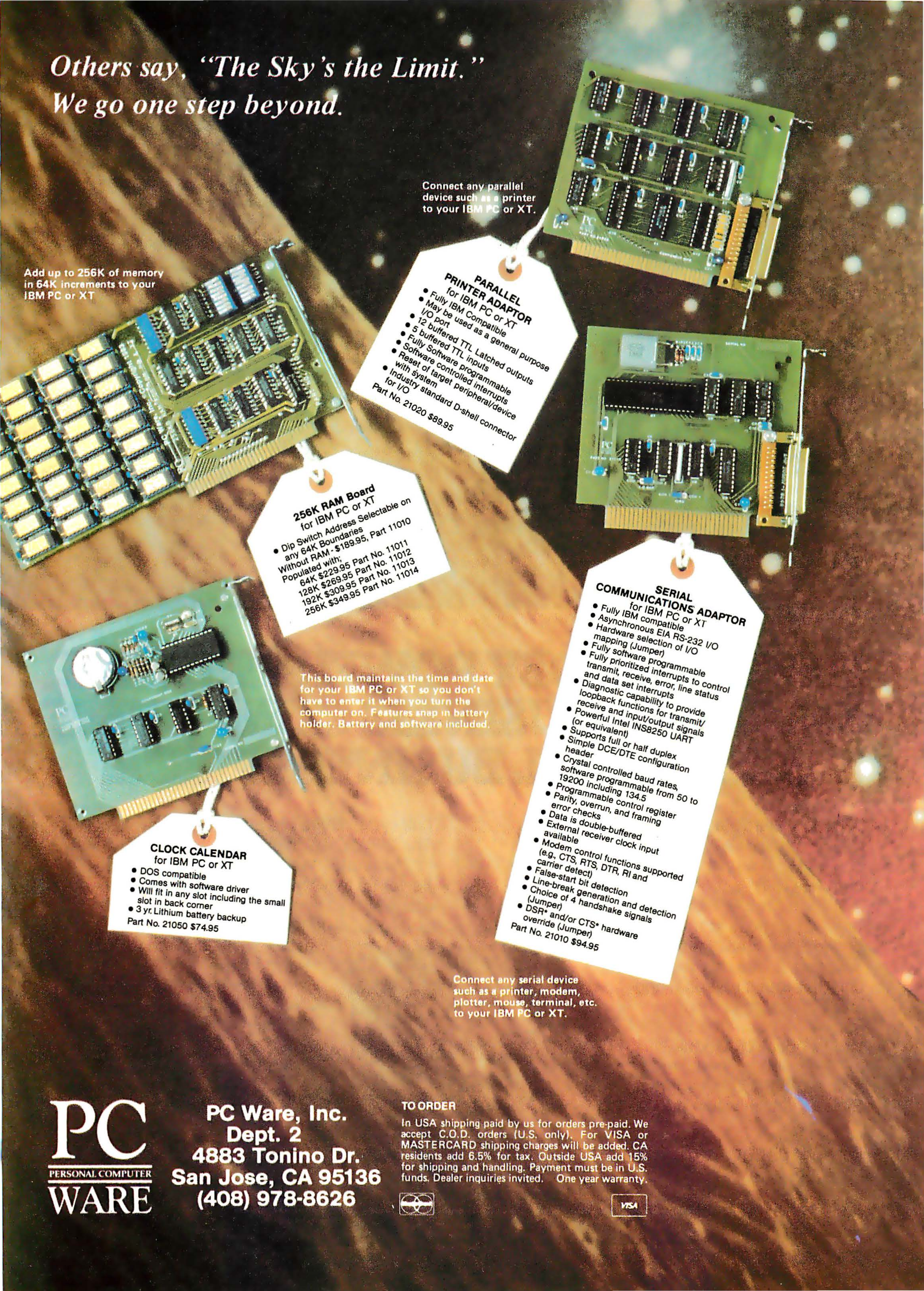


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Simulating Reality with Computer Graphics

by Peter R. Sørensen

Since daguerreotypes became popular in the last century, we have assumed that "the camera doesn't lie." We still assume that the photos we see are accurate representations of reality. But before the invention of the camera, pictures were not taken at face value because they were hand-drawn and subject to the artist's interpretation.

The trust we place in photographs has had a profound impact on communications. It is already possible to create the appearance of metal, plastic, and glass so effectively with computers that the average viewer can't tell if the image is real or not. If techniques continue to improve at the current rate, by the 1990s it will be possible to conjure up almost any kind of scene from a digital description. The implications for entertainment, education, art, and even propaganda are worthy of note. Computer graphics is already one of the most exciting branches of computer science, and it promises to get only more exciting in the future.

Image Generation

You must accomplish two essential tasks very accurately to create believable pictures: perfect perspective and smooth, uniform shading. There are many other factors, of course, but if either one of these two is incorrect, nothing else matters. Any artist trying to paint realistically can attest to the accuracy required to fool the human eye. Although it's extremely difficult to execute flawless perspective with shadows and highlights by hand, the task can be done efficiently by computer.

To generate a picture, you must give the computer the measurements, colors, and reflective properties of the objects in the environment, the point of view of the imaginary camera, the type of imaginary lens (close-up, wide-angle, etc.), and the locations of any light sources. You give the locations in terms of X, Y, and Z coordinates, with X being the width (horizontal), Y the height (vertical), and Z the depth. Many people refer to this process and its products as 3-D because this is a three-dimensional description of the scene. In reality the images are two-dimensional, which is confusing because you can also create true three-dimensional stereo image pairs with parallax on a computer. If you want to animate the scene, you must also specify the motions of the camera and the objects. There are still two quite different software approaches to creating an image: boundary representation (B-rep), the most popular, and *ray tracing*.

With B-rep, the computer needs to determine first the distance of all the objects from the viewpoint and their orientation. Knowing where and how big the objects are (things appear smaller the farther away they are), the system projects a frame of view out into the scene and ignores everything else (called *clipping*). Next, the computer needs to decide which surfaces are



Photo 1: *Jumping Skeleton, created by David Zeltzer of Ohio State University and done at Cranston/Csuri Productions. An artificial-intelligence program automatically animates the skeleton with realistic motion.*


The line between fantasy and reality disappears

visible and which are hidden behind other objects. This is necessary because the computer has an x-ray view, seeing everything at once. To discover how brightly lit the visible surfaces are, the computer must determine their orientation toward the light source. The computer then creates the picture with lines (like a television picture) made up of dots called pixels.

Ray tracing is less frequently used but is currently gaining in popularity. In ray tracing, the computer calculates the paths taken by the light rays. This is a more natural process, except that the computer performs the process backwards: from camera to object to light source. The imaginary film plane is divided like a pixel grid—each pixel is the origin of a ray. The ray emanates into the scene until it strikes an object while the computer traces its path. The angle at which the ray strikes the object determines the angle at which it bounces off and continues on its way. The ray may go on to strike another object or go off into space.

The system can now determine pixel color and brightness from how close the ray came to the light source and how many and what other objects it struck. Everything is calculated strictly according to the rules of physics—how light reflects off different materials or passes through transparent ones—except that things are figured in reverse. If you started tracing the rays from the light source, you'd find that very, very few of them wind up going into the camera, and a lot of effort would be wasted.

A major advantage of ray tracing is that it takes care of hidden surfaces and clipping automatically, just as in real life: you see only what's in your line of sight. This technique saves a lot of computer time; however, ray tracing is still generally slower than B-rep. It's faster to find out which surfaces you can see, calculate their color and intensity, and assign that color/intensity to the appropriate pixels (perhaps hundreds at a time) than it is to calculate each pixel separately with the ray-tracing method. For this reason, most computer-graphics people shy away from ray tracing. However, if you want the superb realism of reflection and transparency, you'll have to spend a little extra time. (This article is *not* an exhaustive comparison of software; there are exceptions to all the rules, and the intent here is to present only an overview.)

Picture generation with a computer is extremely time-consuming, no matter what method you use. Most of the animation in *Tron* took an average of 15 minutes per frame; some took considerably longer. The degree of resolution (the clarity) that you want a picture to have, determined by the number of lines and pixels used to make it, is an important factor in computation time. If you double the number of lines used to get a higher-quality picture, you quadruple the number of pixels used and the amount of time needed. Video pictures have 512 lines, or a quarter of a million pixels. That's very low resolution by the standards of motion pictures; the lowest resolution used in *Tron* was 1,200 lines. When the resolution is very low, you can see the pixels as little squares, which result in diagonal and curved lines having a stair-stepping appearance that's technically known as *aliasing*, commonly called the jaggies. Even at rather high resolutions where

Computer Graphics in Japan

As with all things technical and artistic, the Japanese have become passionate developers of computer graphics. Just a few years ago, their first hesitant steps into scene simulation reached the West and appeared rather naive. At second glance, however, it became obvious that they were making progress at an astounding rate. Indeed, at this year's SIGGRAPH, some of Japan's animation was among the best, in terms of both technical innovation and haunting beauty. What follows is a brief overview of some of the major people and companies involved.

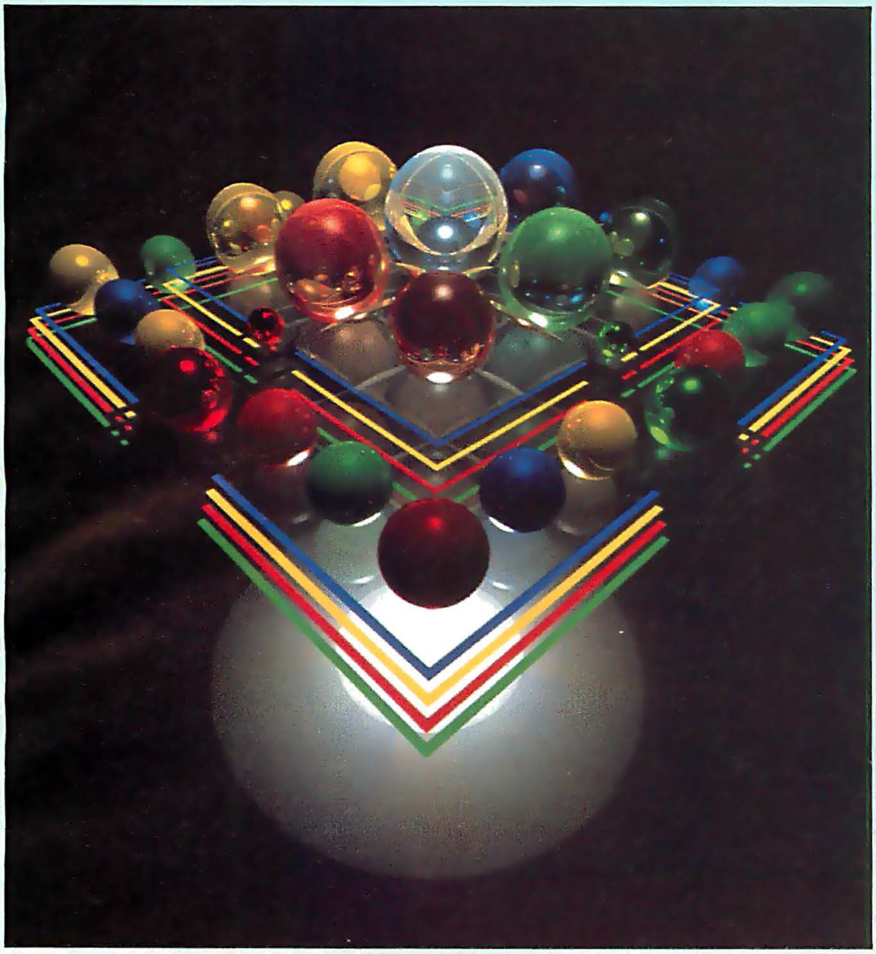
Yoichiro Kawaguchi, a programmer and professor of art at Nippon Electronics College, is perhaps best known in the West. His fascination with plant-growth patterns has led him to develop a "morphological foundation algorithm" that literally grows bizarre and beautiful computer-graphics patterns, branching and spiralling with astonishing complexity. His short film, Growth, Mysterious Galaxy, *brings his art to life. He points out that Dr. James Blinn (see the interview on page 120) helped him with the animation software.*

Another important force, Seibu Digital Communications (SEDIC), used a Cray computer to generate the ultimate (for the moment) ray-tracing film, Mandala 1983 *(see the photo at right). It represents the hierarchy of cosmic forces as a pattern of crystal spheres in a traditional meditation design, changing colors and rotating in space. Richard Hampton, an American programmer working at SEDIC, reports, "With computers coming of age, the heads of SEDIC realized that information would soon become a tangible product. They were interested in the new media. The Buddhists created the Mandala as a means of visually communicating the true essence of the spiritual world to their followers. In the same way we are trying to communicate through the visual."*

Another force in computer graphics is NHK, the huge and progressive state-run television network, responsible for several developments in computer animation including real-time video. The network's talented producer/director, Mayumi Yoshinari, has created several lovely animations, including Origami, *which simulates folding an elegant paper bird in space.*

Dr. Kouchi Ohmura of Osaka University assembled a remarkable experimental parallel-processing computer, LINKS, that in many ways outperforms the Cray. LINKS uses dozens of Z8000 microprocessors, each working on a different aspect of the image, producing all kinds of computer graphics including cartoon animation and ray tracing. LINKS was recently used for some special effects in a movie called Gogol 13. *Keep your fingers crossed that it is shown in the United States.*

The Japanese Computer Graphics Lab is mainly a cartoon-animation facility using several New York Institute of Technology systems for painting hand-drawn characters, but they are becoming involved in simulation. Texnai, a design firm, specializes in computer graphics. Far East Labs uses a system built in Dallas by Acmecartoon as well as a trusty old Scanimate analog computer.



Mandala 1983, a remarkable ray-tracing image done on a Cray in Japan by SEDIC Inc. Musaki Fujihata was the creative director; Kenetsu Hanabusa and Masataka Ohta were the technical directors. With reflections of reflections clearly visible, the picture took the Cray eight minutes to compute at 1024 by 1024 resolution.

the pixels aren't obvious, aliasing can cause edges to "crawl" as objects move, and very small details to flicker on and off.

There are two approaches to the aliasing problem: use very high resolution (tests show, however, that even at 6000 lines there is room for improvement) or try *anti-aliasing* (average the pixels out with their neighbors so the jaggies are blurred and less noticeable). Anti-aliasing tends to soften the whole picture, so you should attack only the offending pixels, which is a pretty tricky process. This smoothing process can save time but it requires some time itself. The decision to use anti-aliasing or high resolution is another point of disagreement among people involved in computer graphics.

Another graphics aspect that is far from being standardized is how a computer models objects. The approach usually used with B-rep is to describe objects in terms of polygons or patches, with front, side, top, and other views. This concept is relatively straightforward and makes even the oddest shapes definable. There are also more sophisticated methods of defining surfaces that rely on higher orders of mathematics, such as *quadratics*.

Another approach, *combinatorial geometry*, is like building with blocks—''primitive'' geometric shapes such as cubes and spheres that are known to a computer—that you can add to or subtract from each other to make compound shapes. You can stretch and distort these shapes (creating an egg from a sphere, for example). You enter the instructions on the keyboard after you sketch the desired shape and think through the construction process. It's not nearly as natural a process as the B-rep method; in fact, you may need to input additional information on a data tablet to create complicated shapes such as type fonts. However, it has advantages: it requires very little memory space, and you get perfectly smooth surfaces without having to take a step to blend the edges of polygons. A sphere is defined by its center point and radius; the B-rep method requires a great many polygons to define a sphere.

Computing the way light reflects off things or passes through them is a subject in itself. The methods have been evolving and becoming more like a study of physics every year. It is now routine to define the subtle differences between the optical properties of plastic and glass, chrome and pewter, ceramic and plastic, and many subtleties in between. In the early days, all surfaces were considered mirrors, bouncing light off themselves and diffusing it equally in all directions according to Lambert's Law. Then Bui-Thong Phong created a more realistic formula that introduced more light-control variables. Now we have the Torrence-Sparrow model, which considers the object's surface to be covered with randomly oriented microscopic mirrors; this comes remarkably close to approximating real life.

What if you want to create a wooden or patterned object? You can scan a photograph or painting with a digital TV camera and project the image onto the surface of your object. This process is called *mapping*; it's the reverse of making a flat world map from the earth's curved surface. With a curved surface like a planet's, the



Photo 2: *Point Reyes, perhaps the most complex simulated picture to date, was done by the digital magicians at Lucasfilm. "The piece is very much a team effort, a one-frame movie," with mountains, rocks, and lake created using fractal programs written by Loren Carpenter, plants by Alvy Ray Smith and Bill Reeves, and textures by Tom Porter. All of the art was directed by Rob Cook, who created many of the details, including the rainbow.*

picture wraps around the object and gives it a natural-looking perspective as it moves about. You can also map certain kinds of textures onto surfaces, like the bumpiness of an orange, with each bump having its own shadow (a process known as *perturbed normal texture mapping,* developed by Dr. James Blinn of the Jet Propulsion Laboratory).

So far I have focused on generating a single realistic image. There are a few additional considerations if you want to animate a scene. You must choreograph the motion desired and describe it to the computer. You can trace it out on a data tablet or type in commands, like a movie director telling the actors what to do: "Go from point A to point B taking three seconds and accelerating as you move." Directions must be given in the language of the software. The motion becomes rather complicated when you have moving parts on moving objects in a scene observed by a moving camera. A classic example is a flea walking around on an elephant's head while the elephant nervously paces back and forth on a raft floating down a river. The camera's view is called the world space, the raft is a parent space, the elephant is a daughter space of the raft, and all the elephant's appendages, to say nothing of the flea, are daughter spaces of the elephant. All this is handled by a tree structure showing these various relationships.

Motion is an important element in making or breaking the believability of an image. When a ball bounces, its acceleration and trajectory tell a lot about it; a Super-Ball behaves one way, a Nurf Ball another. To more precisely portray motion, some computer-graphics designers are beginning to incorporate artificial-intelligence routines into their software.

The last step involves turning the millions of bytes into a picture on a monitor or a piece of film. Essentially it's a straightforward process of converting digital data to analog form. You can then record the signal on videotape or display it on a monitor. In the case of movie film, the signal paints the picture on a high-resolution monochrome video display mounted beneath a movie camera that shoots one frame at a time. The camera's shutter stays open while the computer generates three consecutive images, using color filters for each of the three primaries.

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Photo 3: *Alvy Ray Smith, with the help of colleagues at Lucasfilm, created this deceptively simple-looking work of art entitled White Sands. The flowering plants are grown in three dimensions from a single "cell" using an algorithm written by the artist, based upon mathematics by Paulien Hogeweg. The grass is done with a procedural modeling technique developed by Bill Reeves. The oriental characters form the artist's name.*

Why not just take a camera and film the real thing?" Obviously, if you *can* film the real thing, you should. But if you want to film a Model T turning into a Thunderbird, in an improbable but believable organic metamorphosis, scene simulation is the only answer. Or, if you want impossible camera angles, like an atom's-eye view of a molecule, or a tour around the inside of a computer chip (anything that defies the physically possible), image synthesis is often the only way to go. Frequently used in TV commercials, this technique promises to become in the near future an economical alternative to constructing movie sets and to some kinds of location shooting. Image synthesis is important in other fields too, such as medical CAT-scan imagery, product design, and flight simulation. As miniaturization progresses, we can look forward to many of the capabilities now available on mainframes becoming possible on microcomputers.

There are obviously a great many doors opening in computer graphics today. I interviewed several major figures in the field, including John Whitney Sr., generally regarded as the "Father of Computer Animation," and Dr. Alvy Ray Smith, who is working on George Lucas's remarkable computer-graphics research and development project. The insights and advice from these experts cover all aspects of the field. They occasionally even contradict one another, which doesn't mean one is right and the other wrong, but rather indicates that this business is still very much in its formative years.

Alvy Ray Smith (Lucasfilm)

The work being done at Lucasfilm is revolutionary and almost certain to have a profound impact on the entire entertainment industry. George Lucas, creator of the *Star Wars* saga, became interested in the possibilities of computers several years ago, hired a team of the best software and hardware people he could get, and gave them a mandate to develop a system that would bring motion-picture special effects into the 21st century. He actually wanted several different systems to provide different capabilities: computer imagery, digital matting, sound synthesis and mixing, a laser scanner to print the final product onto film with first-generation quality, and a totally computerized editing studio called EditDroid, with all the footage shot for a film on videodiscs, enabling totally interactive editing.

The team developing the Pixar image generator included Rodney Stock, Adam Levinthal, Mark Leather, Glenn Sharp, and Tom Porter on hardware; Alvy Ray Smith, Rob Cook, Bill Reeves, Sam Leffler, and Loren Carpenter on software; both groups were directed by Dr. Ed Catmull. They set a three-year goal and put their noses to the grindstone, pausing only briefly to create film footage—the "Genesis Demo" for *Star Trek II* and the display of the force field around the moon of Endor in *Return of the Jedi*. The work progressed on schedule despite the inevitable difficulties, but rumors of failure began to circulate among the competition.

My first question to Smith concerned whether the project was doomed. "These rumors probably came about because people have been expecting us to do all this in three weeks. All prototype devices have difficulties—that's normal. We said it would take about three years; the three years are just about up, and the system is just about to roll out the door. We're very pleased. The boards for our Pixar are starting to come in, our laser scanner is now making color moving pictures, software systems are up, and we're doing a little in-house film with motion blur and all to demonstrate the system's capabilities." (Motion blur, sometimes called temporal anti-aliasing, is very difficult to simulate, but it adds a great deal to the natural quality of an object's motion.)

Why did Lucasfilm decide to build their own hardware from scratch, with all the time and risk involved, instead of buying a system off the shelf? "You can't just buy something like that," Smith said. "True, there are supercomputers that we would be glad to use, but even they are a little slow for what we want to do. So while we are waiting for the price of these machines to drop, we are building a machine especially designed to implement graphics algorithms—one that costs significantly less.

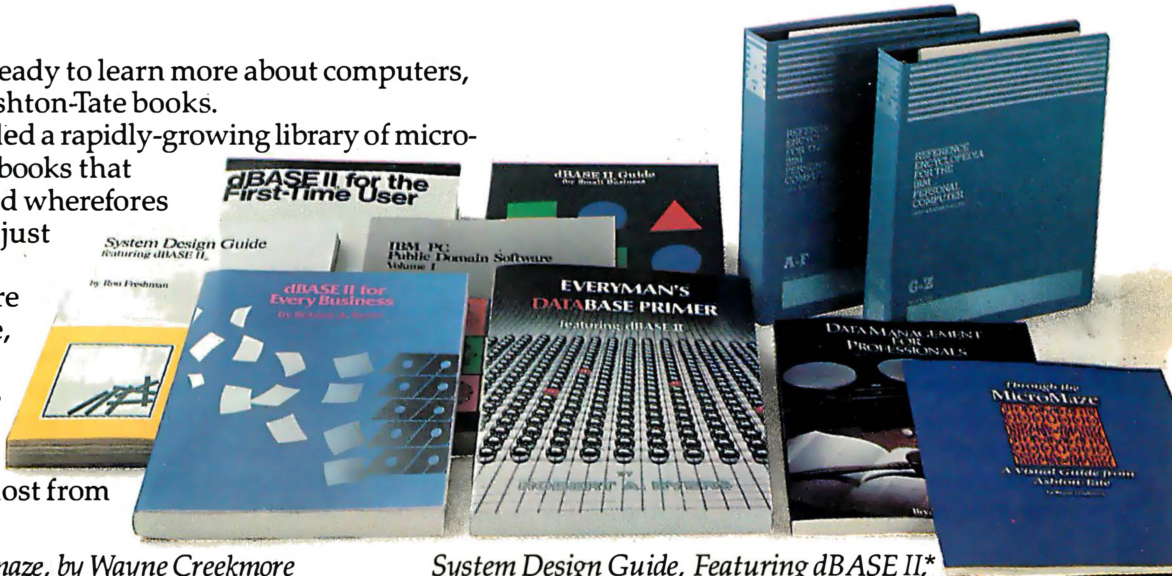
"You know, we are *not* limited to scene simulation, so I much prefer

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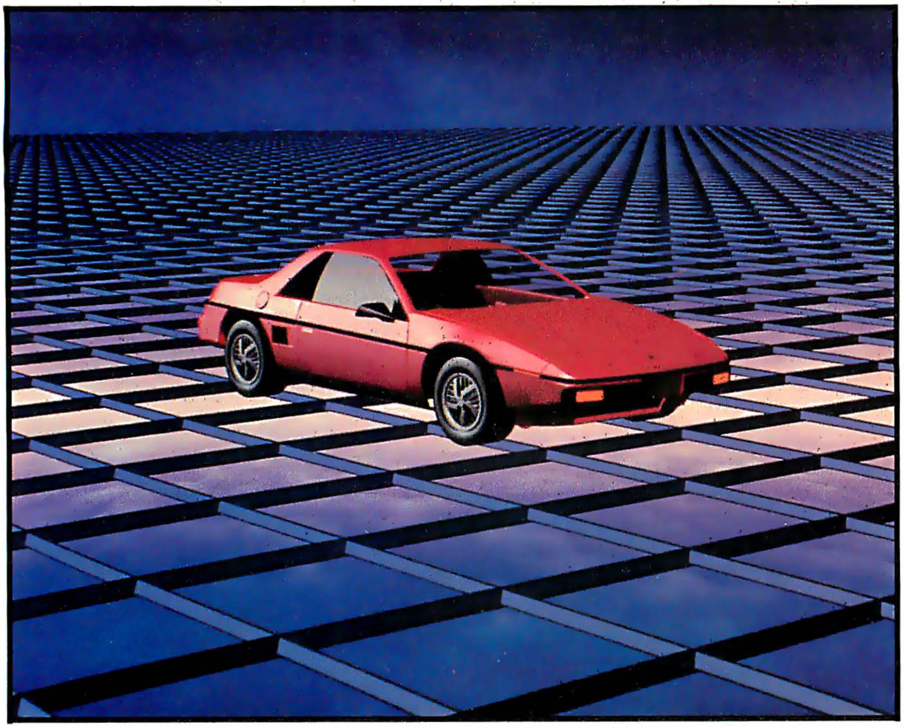


Photo 4: *Using the manufacturer's blueprints, the Cray at Digital Productions simulated this Pontiac Fiero, which assembles itself from pieces that fly in from all directions. Mario Kamberg and Jim Rygiel were the creative and technical directors, respectively. (Digital Scene Simulation (sm) by Digital Productions, Los Angeles, CA. ©1983, all rights reserved.)*

the term *computer imagery*. Reality is only a measure, not a goal."

Advice? "It's not easy to get into computer graphics, but I suspect it's going to get easier. People will be making pictures with computers from now on, and anyone who knows how will be in demand. Go to school and learn how to program; find out how graphics algorithms work."

Photos 2 and 3 are examples of Lucasfilm's work.

Patricia Cole (Atari)

The people at Atari's advanced graphics research and development division are interested in both games and motion-picture special effects and work at times with Lucasfilm. Pat Cole is in charge of the division and was previously with Lucasfilm, the Jet Propulsion Laboratory, and NASA.

The creation of the computer-generated visuals for *Superman III* in 1982 was one of her first jobs. "*Superman* needed the immediate visual impact of a video game, but with better than current game technology. We decided to do a two-and-one-half-dimension computer animation. [Flat images with some spatial aspects are called 2½-D.] We built a software system for this on top of an existing system we use to develop our games, programming in LISP on a Symbolics LM2 under Paul Hughett's leadership. In the meantime we have also been establishing a full-blown three-dimension image synthesis animation facility—technology which is literally right around the corner for us. This is primarily oriented toward developing videodisc games, but we aren't drawing too many boundaries. As the facility grows and develops a personality of its own, we want to be able to do other types of projects."

Cole offered some advice. "The first decision a person has to make is whether they're more interested in the creation aspect or the technical aspect. This isn't necessarily an either/or situatior:, but the ideal is to have some people who are primarily creative and others who are primarily technical, knowing that talents overlap and merge. I don't encourage artists to go back to school and get a degree in math, but you should get as much experience, even working on a home computer, and exposure—going to conferences and seminars, like SIGGRAPH—as you can. Become familiar with the jargon and with the capabilities and boundaries of the technology. Similarly, people with a technical background would benefit greatly from a basic course in design and from visiting art museums and getting an appreciation of the artistic world. The ideal goal is a common visual vocabulary, a common communication, so that this overlapping knowledge can increase."

John Whitney Jr. (Digital Productions)

The world's most powerful production computer, according to *The Guinness Book of World Records*, is the Cray XMP. The first of these magnificent beasts belongs to Digital Productions, a company founded by John Whitney Jr. and his associate Gary Demos. (Photo 4 was created by Digital Productions.)

Growing up immersed in state-of-the-art movie technology, Whitney did the first computer graphics for Hollywood movies, *WestWorld* and *FutureWorld*, at Information International Inc. (Triple-I), working with Demos. They coined the term Digital Scene Simulation*. In 1982, Whitney and Demos got the funding they needed to lease their first Cray 1/S. It had about one-third the power of the current model, but it was the most powerful machine available at the time. Soon after they opened shop, Lorimar Productions brought them their first job: to do about 40 minutes worth of simulation for *The Last Starfighter*.

"Getting the XMP is a major development. The combination of the new hardware and continued improvements in software will give Digital Productions a major thrust forward. Databases of 1 million polygons on the 1/S computer began to require an unacceptable amount of time per frame. We hope to compute scenes with the XMP on the order of 1 million polygons plus and still maintain a speed of 200 seconds per

*Digital Scene Simulation is a service mark (sm) of Digital Productions.


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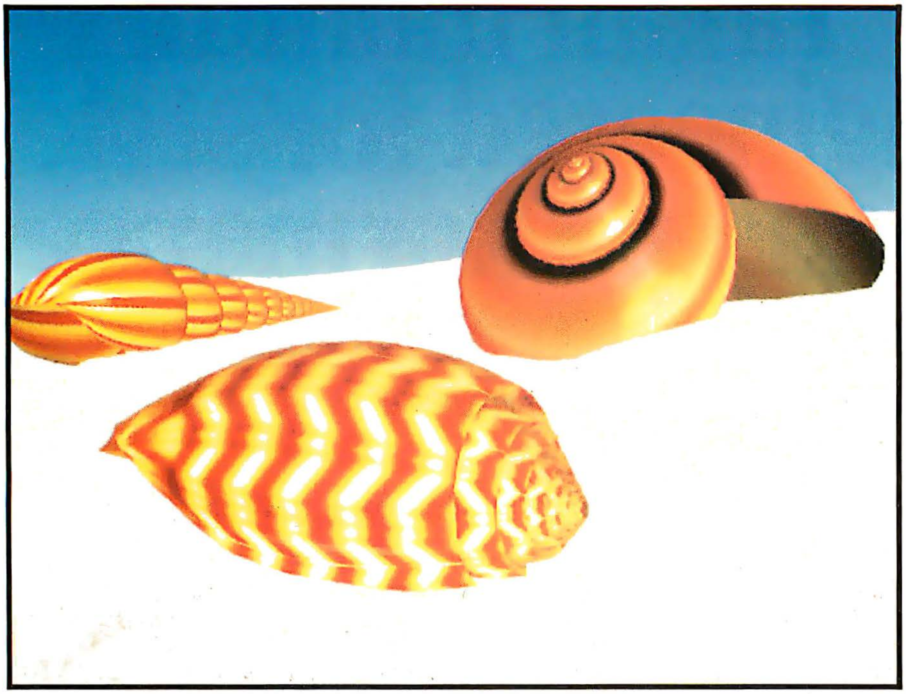


Photo 5: *Low Tide, by Peter Oppenheimer. These seashells with the patterns mapped onto their surfaces were generated by a spiral growth-simulating algorithm. (© New York Institute of Technology Computer Graphics Lab.)*

frame, where we like to be. Even so, our appetite for greater scene complexity never seems to end."

To talk to the Cray, Whitney explained, "Digital Productions uses a VAX 11/782, which is a user-friendly, interactive front-end processor. The VAX provides a programming environment for software development and handles front-end operations for productions that are not practical on the Cray. We also have the Cray I/O [input/output] subsystem (a buffer memory and multiple-processor computer that provides access to the XMP high-speed channel) in operation at this time. The high-speed channel is required to optimize high-bandwidth data transfer, desirable for film recording and scanning operations, and to more efficiently utilize color-monitor workstations.

"Many organizations today claim to use computers for special effects, but the claims are often exaggerated. Using an Apple, for example, in a process- or numerical-control installation [i.e., a small computer running a mechanical process such as a motion-control rig] hardly constitutes computer graphics. Also, many creative and talented art directors are working with computer graphics where the computer output is only a small part of the end product. I would advise art directors not to become used to this sort of interim, transition-level computer graphics. Simulation implies an ability to create live action with a high-performance computer. In special-effects production, this means that the struggle to combine a half-dozen different techniques is as passé as a turn-of-the-century sweatshop. The challenge to the art director who wants to create something unique and refreshing is to remain open-minded in exploring mature simulation opportunities."

Whitney's advice: "A background in computer science oriented toward graphics is certainly a basic requirement. Beyond that, if someone is serious about pioneering in the field, then numerical analysis and very high-level mathematics are mandatory. There are a few institutions, MIT, Cornell, and the University of Utah, that offer graduate educational opportunities in computer graphics."

Howard Gutstadt (General Electronic Systems Inc.)

Of course, graphics can be done on microcomputers. General Electronic Systems Inc. (GESI) is doing that very intensively. The company is building systems for industrial video applications capable of doing two-dimensional and some three-dimensional animation with the new Sony microcomputer. The system is a natural for a videodisc arcade game that overlays real-time graphics on top of the disc images.

I asked Howard Gutstadt, GESI's vice president, why the company uses the Sony instead of a more popular machine. He responded, "One strong rationale is that the Sony is designed to interface more effectively with video-type applications than other micros. It combines an inexpensive approach to computer graphics with a reasonable color palette and a sophisticated approach to machine control of videodiscs. It contains all the necessary I/O to control the associated machines. In addition it has two other very important features: genlockable input for video (the computer can be on line between the source materials and resulting video materials and still give you video that meets the standards of the National Television System Committee; for microcomputers that's a real pain to achieve) and specialized circuits (you can integrate the graphics you generate with the disc material, avoiding the need to buy a post-production switcher). In addition, you can write any interactive scenario in software and run it with graphics from a floppy. And it's all relatively inexpensive—the central processor is less than a thousand dollars."

Lance Williams (New York Institute of Technology)

People in the field consider the New York Institute of Technology (NYIT) to be one of the foremost centers for computer-graphics research and development. (See photo 5.) NYIT is also a hardware producer and a production facility for all kinds of state-of-the-art animation. The Computer Graphics Lab was founded in 1974 with Ed Catmull (now with Lucasfilm) in charge. Many greats in computer graphics, including Jim Blinn and Alvy Ray Smith, have passed through its doors and contributed to the evolution of

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Photo 6: *An X-Wing fighter done by Art Durinski at Information International Inc.'s now closed motion-picture division. (This image was created for the cover of IEEE Computer.) The successful simulation of the Star Wars spacecraft convinced George Lucas that scene simulation is an important special-effects tool.*

the systems there. Today, Lance Williams spearheads development. He is working on, among other things, a system called 3-DV. It will be composed of off-the-shelf components including a 68000 microprocessor and an Adage high-performance bit-slice processor, running scene-simulation software. Williams said he expects the system "to be two or three times as fast as a VAX."

At the time of this writing NYIT has eight VAXes, two DeAnza array processors, two floating-point array processors, many frame buffers, and three Ikonas processors with a lot of frame-buffer memory on them. Much of the Institute's work is done on video, both 2-inch and 1-inch, and film recording is done with a Dicomed or one of two Dunn Boxes.

NYIT has a computer-graphics course taught by Robert McDermott. In addition, there are computer painting facilities in the design department, computer special-effects facilities in the TV department, and an Evans & Sutherland Picture System with three-dimensional modeling capabilities in the architecture department. NYIT's main facility, however, is an independent research and development department that is not part of the school proper. "We have hired students here to work as computer operators," said Williams, "but there are not enough people involved to recommend this as an entry into a career.

"Usually I recommend that you get a technical background; even if your major interest is design, it will help a lot to have technical skills. You'll be able to do more with the machine and to get jobs. You have to acquire some technical expertise. The first thing is to learn a trade, a basis you can build a career on, developing some sound, expensive skill. You want to become a good programmer and a good animator. Animation is a dying art. There aren't many places that teach it anymore. [Exceptions include the California Institute for the Arts and the Rhode Island School of Design.] Also learn as much as you can about photography. Computer graphics is an exploding field. The opportunities are springing up everywhere, although the competition is stiff."

Art Durinski (Freelance Designer)

Tron, unfortunately, wasn't a blockbuster movie. Consequently, the moguls of motion pictures threw the baby out with the bath water and assumed that the public wasn't interested in computer graphics. That was very unfortunate for many computer-animation companies. The firms were expecting a lot of business after *Tron* and some of them went out of business instead. Triple-I, which had done the Solar Sailer and the MCP for *Tron*, closed its motion-picture division within a year of the movie's release, putting some of the most talented engineers and designers out on the street. This included designer/director Art Durinski. For a while he worked with Digital Productions, but eventually he decided to go independent as a freelance consultant.

"The popularity of computer graphics in entertainment," he said, "isn't rising as quickly as expected. It's going to take a major successful movie. Hopefully, *Starfighter* or *Gogol 13* will be nicely stylized and have a good story. That could do it. In four or five years, people will accept the computer look as a new kind of reality. (See photo 6.) I don't agree with the philosophy that everything must look photographically real. Computer graphics should have its own unique and exciting look, and not necessarily try to pass itself off as real. *Tron* and *Fantasia* were never

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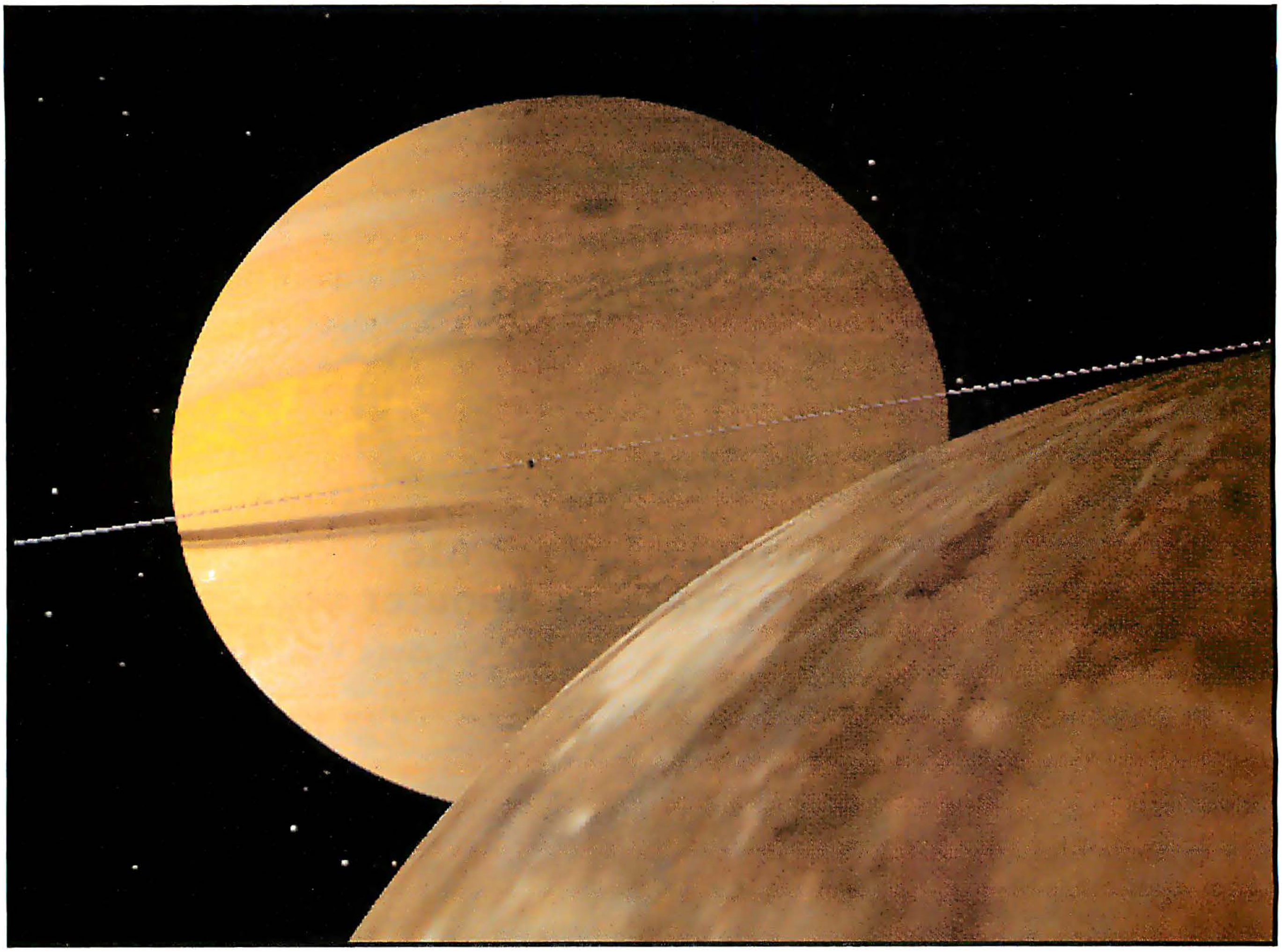


Photo 7: *Saturn seen from her moon, Rhea, as rendered by James F. Blinn at Cal Tech's Jet Propulsion Laboratory for NASA's computer-generated film about the flight of the Voyager spacecraft. The surfaces are painted flat and mapped onto the spheres.*

meant to look real, but they hold together beautifully."

Durinski's advice: "If you are excited about this field, just coming out of school, changing careers or whatever, I don't think that there is an easy way into three-dimensional computer graphics in entertainment yet. You might get a job at an analog house first and then migrate into three-dimensional animation when a job opens up. The situation in TV is much better than in films right now, but the opportunities are not really there yet."

James F. Blinn (Jet Propulsion Laboratory)

One of the foremost innovators in scene-simulation software, Dr. James F. Blinn, studied at the University of Utah in the early 1970s. Dr. Ivan Sutherland was teaching there then and it was a mecca at the time for people interested in computer graphics. Since then, Blinn has worked at a number of places including NYIT, Triple-I, and Lucasfilm, but mostly at the Jet Propulsion Laboratory at Cal Tech. There he combines his three loves: computer graphics, astronomy, and teaching. His animations of the Voyager missions to Jupiter and Saturn are very well known, having been broadcast by all the national networks when the spacecraft was passing those planets (see photo 7). The imagery was so realistic that many people were puzzled as to which were the synthesized pictures and which were the real ones sent back by the ship's cameras.

Blinn is currently doing animations illustrating the laws of physics for Community College Television's series, "The Mechanical Universe." He is working with Cal Tech professor David Goodstein, the writer/designer of the series. One program, for instance, shows how the movement of the planets is a natural consequence of Newton's laws of motion, and why the planets have elliptical orbits. The animation is done on a VAX 11/780 with a DeAnza frame buffer and is recorded on 1-inch tape using a Lyon/Lamb controller.

When asked about the poor performance of *Tron* at the box office despite the beautiful special effects, Blinn pointed out, "A human being makes a good movie—not a committee. Powerful figures like a George Lucas or an Alfred Hitchcock make a good movie because it's their movie, their creative energy. They don't have a group of bankers telling them what to do."

Although many people in computer graphics demand state-of-the-art systems, Blinn's reaction to that approach was, "State-of-the-art

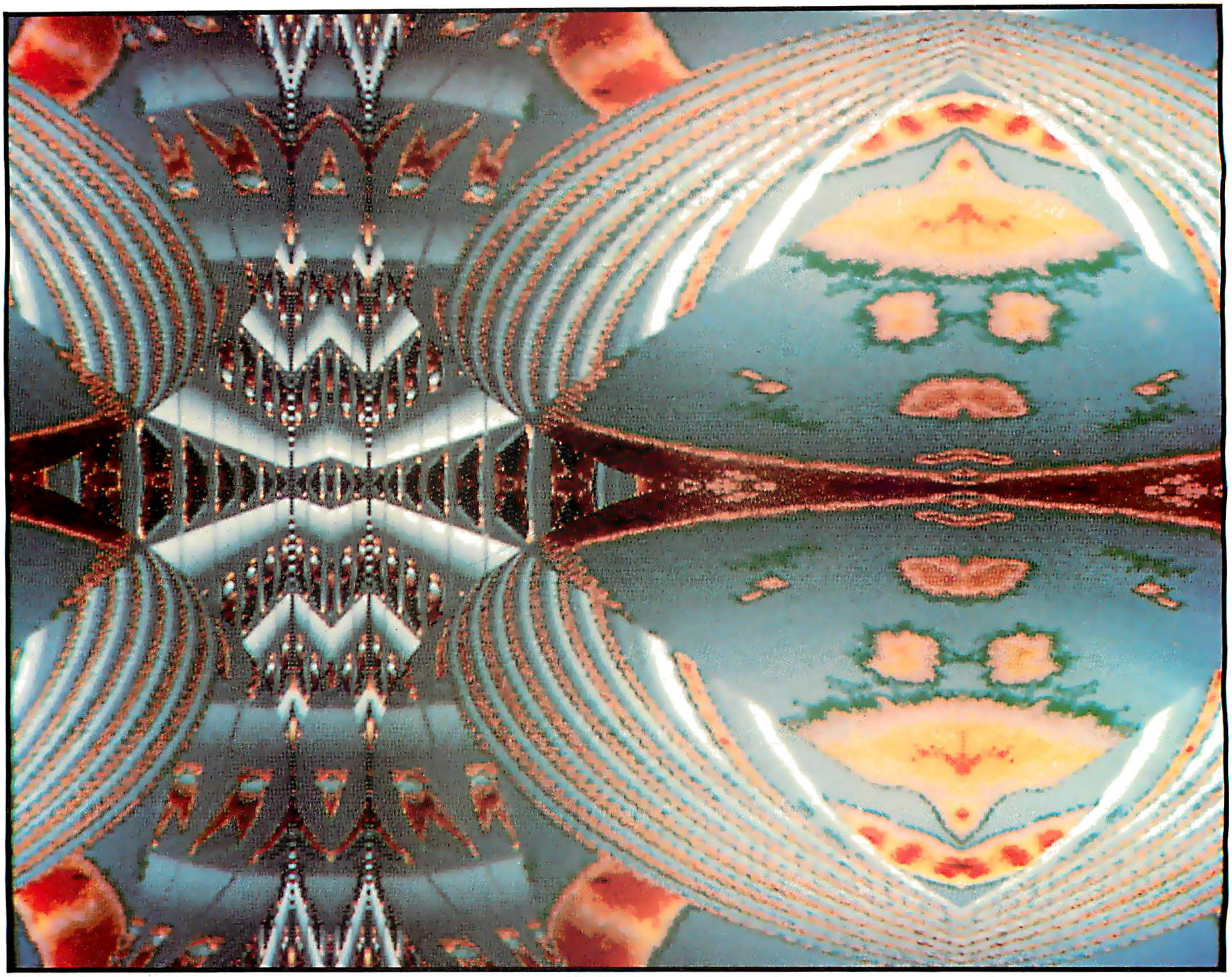


Photo 8: *Suma, a digital creation by David Em, was done at the Jet Propulsion Laboratory using software written by James F. Blinn. The artist uses the computer so that much of his art is like painted sculpture. This is a result of the mapping technique that permits him to take an image, distort it, and use images inside of images, resulting in a staggering complexity. (© David Em, 1979, artist.)*

means that it doesn't work 90 percent of the time! You can use state-of-the-art equipment and do pictures very quickly for half an hour, and then your computer is down for the rest of the day. I'm not interested in using exotic hardware. I want absolutely plain-vanilla, off-the-shelf hardware that works consistently and is readily serviced."

Blinn recommended a formal education as the best way to get into the field. "I went to school and studied computer science."

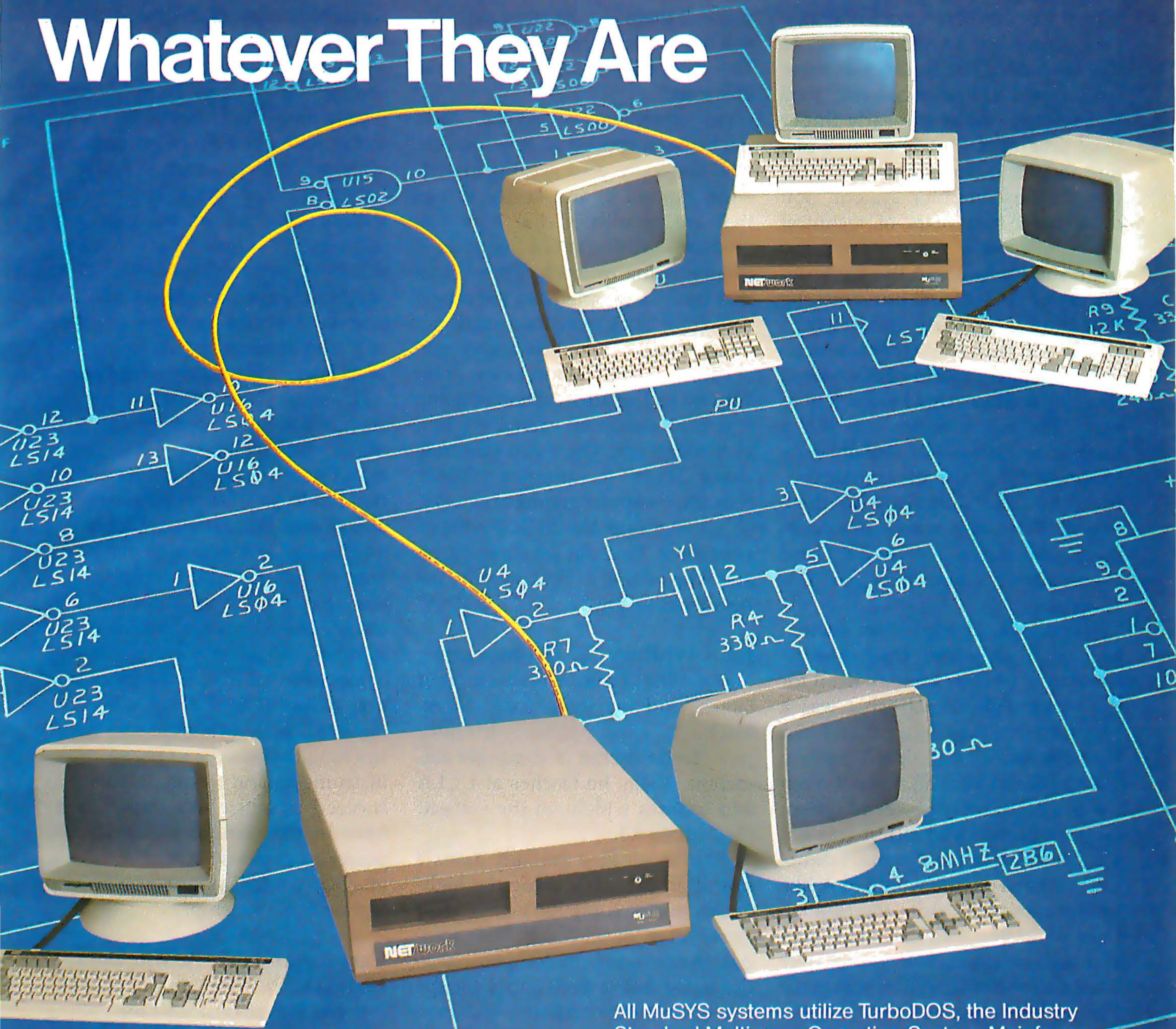
David Em (Artist)

Probably the foremost computer-graphics artist in the world today is David Em, an eclectic whose interests include painting, theater, and dance. His fantastically complex digital creations (see photo 8) rely heavily on the computer's capability to take an existing image and work with it, making it three-dimensional, mapping it onto a cylinder or some other complex geometrical shape. Much of his work has been done at the Jet Propulsion Laboratory, using James Blinn's software. He builds gem-like environments of staggering complexity with a technique of repetition (pictures inside of pictures inside of pictures).

Em's artistic talent first bloomed as a child in Colombia. He gained a reputation as a painter and sculptor many years before becoming involved in electronic media. "It's been 10 years since I decided to go into the electronic side of things. But before I had even heard of computers I was making sculptures in factory environments. To do that I had to work with complex machines and establish relationships with the company president, the supervisor, and the worker who operated the machine. I didn't realize at the time that I was learning the skills that would enable me to work with programmers, managers, and high-tech scientists later on.

"You must learn to interface with personalities as well as with machines. There are three fronts that all have to be kept up: you have to have your machine act, your people act, and your creative act all working in parallel.

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"The first computer I actually worked with was at the Xerox Palo Alto Research Center in January of 1975. It had that first frame buffer that Dick Shoup got up and running. At that time Alvy Ray Smith was there with David DiFrancisco, and they had written one of the early Super Paint programs. I made my first picture about an hour after my introduction to the computer system. You don't need two years of technical study to make a picture. True, the more you know about the medium, the better off you are, but since the programs were fairly interactive, I was able to create a picture practically from scratch. I kind of discovered this new medium that I knew had to exist. The frame buffer was like a mystical revelation—I'd actually been looking for this specific instrument. Everyone said it didn't exist but there it was! Then the whole operation there shut down later in 1975 and eventually I came back to Los Angeles.

"Then I was at Triple-I for about a year after they did their historic simulation of Peter Fonda's head for the movie *FutureWorld*. That was a very different experience than I had with Xerox. The Triple-I system wasn't interactive at all. Even though it was a much more powerful system (high resolution and all), it was not a viable creative tool for me. I didn't know what a picture would look like until it came back from the film lab three days later. A frame buffer gives you instant, interactive control over what you're doing. When you make a picture, whether you're a designer or a filmmaker, you make millions of little decisions that you don't think about until you have to start specifying them."

During this time Em established a relationship with the Jet Propulsion Laboratory. Working late at night when the equipment was available, Em began using digital paint, texture mapping, and other leading-edge processes that had synthesized the solar system for NASA, to create his own fanciful universe.

"If you're pushing the state of the art, the process is more important than the parts. You have to get everything working and talking together. Some of these processes are as old as the hills, like storyboarding, and some of them are the latest capabilities that civilization has brought us. The computer is just one of these elements."

Em offered some advice. "You might be surprised at how quickly you can apply your existing knowledge, expand it, and do the things that are peculiar to the high-tech medium. You don't need five years of programming or math. Those fears that creative people have are a psychological block more than anything. Just start doing computer graphics on any level, whether it's in a class or on your own. The actual action of doing it is very important even if it's in a very rough way. Once you start, one thing leads to another. Oddly enough, computer graphics is a *scene*, so go to things like SIGGRAPH in your town. Find out what's going on and who's doing it. Find out who the personalities are."

John Whitney Sr. (Filmmaker)

John Whitney Sr., with his brother James, and his three sons, Mark, Michael, and John, literally pioneered the craft of computer animation. Today he teaches at UCLA and lectures widely on the subject. (See photo 9.)

Whitney recalled the early days. "I started in the 1950s using the high-quality analog computer systems that came out of World War II. They were designed to solve the complex ballistics equations of fire control for the anti-aircraft gun batteries, and here I was making design machines out of them! I didn't have any engineering background at all when I began to adapt this kind of equipment. I didn't realize how significant it was that they represented the beginnings of the advanced problem-solving computers. In a sense, I stepped backward into computer graphics. Only after I became competent with the equipment did I begin to realize that I was really trying to build my own computer. By the 1960s, industrial computer graphics was underway and being used extensively in scientific circles. I applied to IBM for a research grant in 1965 and benefited from it until 1970.

"I would never claim to have foreseen the coming of computer graphics as it is now. It was the other way around—I could see that my vision of abstract design and color, in completely pure, fluid motion, was going to be quite possible with computer systems. In fact, a year or two after I started, I made a film showing the tedium involved in making computer-graphics films! But I expected that the systems would become smaller, cheaper, and faster, and that one day I would have one, the size of a television set, in my home. Ten years later, that's exactly what I have.

"I am confident that we will be able, in a single system, to compose music and color design, bringing a brand new world of rhythm and action ready for a brand new breed of artists and composers. There's no question that it will start the same kind of cultural and social phenomena that has always been true in music. The only reason we have outstanding rock singers and pop-music composers is because for every one that makes it to the top, there are hundreds of thousands of youngsters teaching themselves to play musical instruments and to sing, aspiring to succeed in music. It's important to have in the composer's hands the power to compose both sound and image in a totally interwoven and integrated relationship."

Carl Rosendahl (Pacific Data Images)

If you have a difficult time getting a job in computer graphics, you might consider Carl Rosendahl's approach. Fresh from school with a degree in electrical engineering, he started his own company on a shoestring. In a short time his company has grown to where it is doing work for national and international clients, including the opening animation for "Entertainment Tonight" (see photo 10).

"I started the company three years ago, and the first year and a half I was alone, trying to figure out computer graphics. I knew computers pretty well, and I knew film, because I grew

up in Los Angeles and made movies all through high school. I spent that first year with a little Cromemco computer, reading the SIGGRAPH proceedings and figuring things out. Then I got a PDP 1134. That's when Glenn Estes and Richard Chong joined me, and we spent the next year developing software. Six months later we got the VAX 11/750, and although it took three weeks to get the VAX running, it only took about 36 hours to load all the software and have it up and running. Then in May of 1983 we opened our doors for production."

"We do everything in video resolution, 512 by 486, 24 bits per pixel, so it's full color and it's all anti-aliased so you don't get any jaggies. Each picture takes a quarter of a megabyte, so a 10-second spot generates about 225 megabytes of picture data. When you get into 60-second commercials, there are gigabytes of data. All our machines are running Unix, and all our code is written in C. There is no assembly language or microcode that allows us to develop code on one machine and run it on all the others."

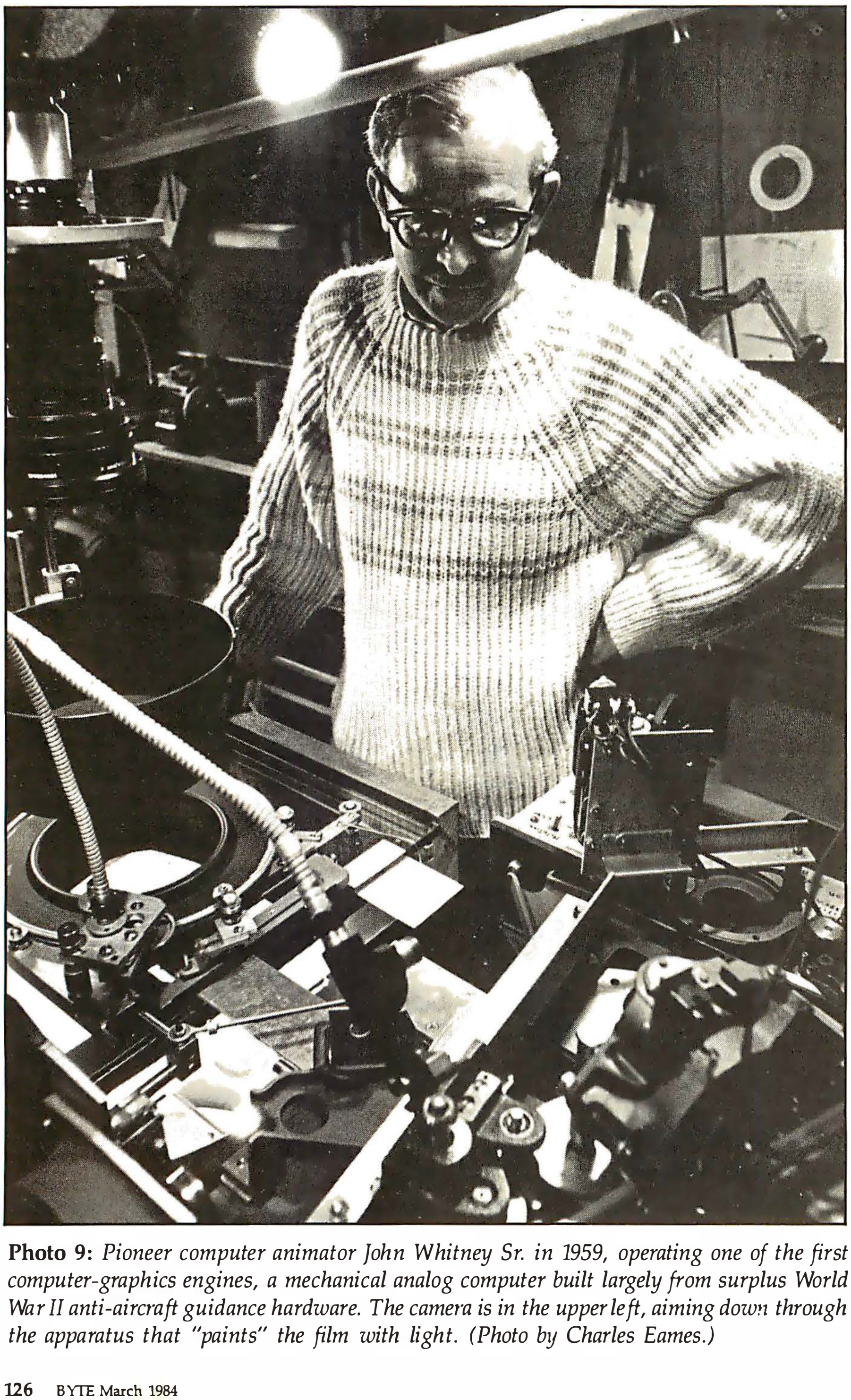


Photo 9: *Pioneer computer animator John Whitney Sr. in 1959, operating one of the first computer-graphics engines, a mechanical analog computer built largely from surplus World War II anti-aircraft guidance hardware. The camera is in the upper left, aiming down through the apparatus that "paints" the film with light. (Photo by Charles Eames.)*

Rosendahl's advice: "An understanding of the geometry and math involved and good three-dimensional visualization are really important because the modeling and motion design must happen in your head before they can happen in the computer. Being able to visualize what you're building is very necessary. If you want to work closely with the clients on production, you have to be able to communicate with them artistically rather than technically. There is also a big need for people doing development—creating the tools to use in production—where artistic ability isn't as necessary."

Bill Kovacs (Robert Abel & Associates)

Bill Kovacs is a software designer and vice president of Robert Abel & Associates. He came to Hollywood to work with Robert Abel on the special effects for *Star Trek, The Motion Picture.* He devised a way to use an Evans & Sutherland Picture System to preview choreography that would ultimately be filmed with models on a motion-control rig. Although politics and production problems eventually took the *Star Trek* work elsewhere, the computer-graphics work proved so successful that it became a mainstay of Abel's special-effects business.

Recently, Kovacs used the new IRIS computer from Silicon Graphics to assemble a raster system capable of scene previewing, which is a formidable tool in the hands of the company's designers. "It's the first unit shipped in the U.S.," he said, "and it's wonderful. It can do real-time shaded graphics of limited complexity, or it can do nonreal-time graphics of very high complexity. And it's totally compatible with our Unix system. It runs on Ethernet, the *in* way to connect one computer to another."

In addition to commercials for Corvette, 7-Up, and TRW, Kovacs and the Abel team recently did the animation for a videodisc arcade game, Cube

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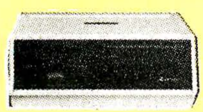
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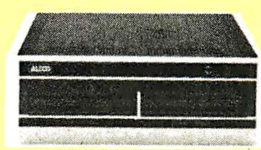
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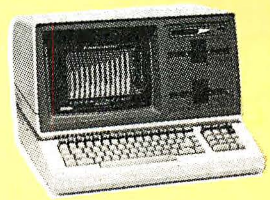
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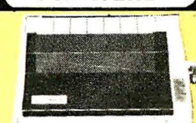
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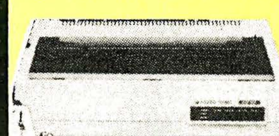
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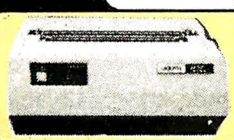
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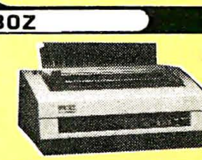
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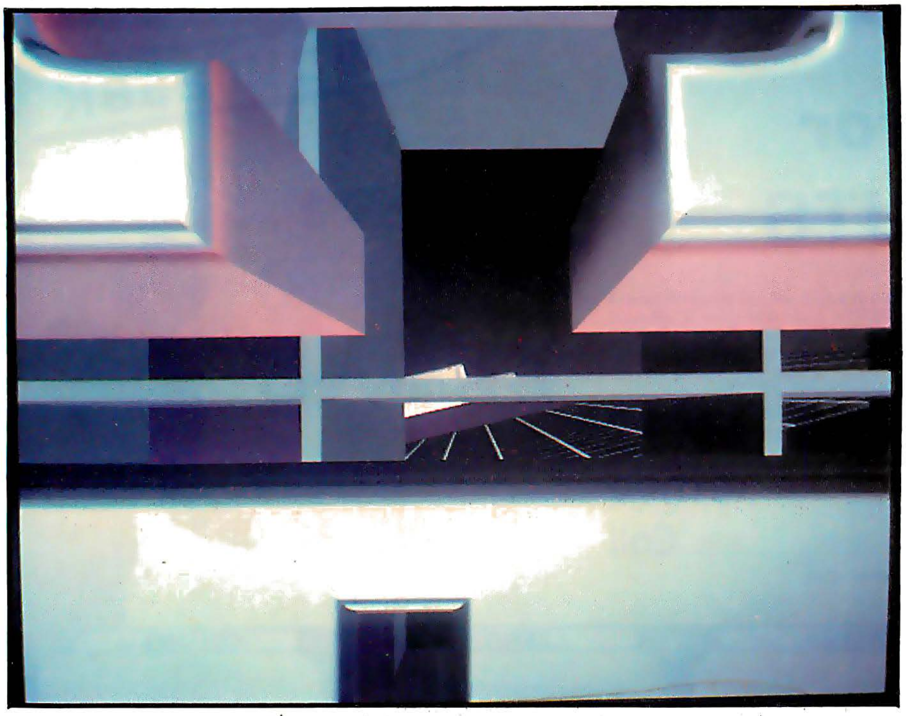


Photo 10: *The opening title animation for the television show "Entertainment Tonight," done by Carl Rosendahl of Pacific Data Images. The sequence is created using smooth-shaded polygons and anti-aliasing.*

Quest, for Simutrek. Kovacs explained, "The game uses laser videodisc technology overlaid with—and this is the key—very sophisticated, real-time, three-dimensional, shaded computer graphics. This is new for the industry.

"Business people still don't appreciate the value of software. They go out and buy expensive hardware but don't hire a good software person to go with it. It's so stupid! It's like racing formula cars when you can afford the cars but not the high-priced mechanics. If you can't afford both, you shouldn't be in the racing game. Some companies are so intimidated by the computer that when it arrives, they step around it, always staying five feet away. They're afraid that it might break if they touch it and they might have to pay a couple hundred dollars for maintenance."

Vibeke Sørensen (Artist and Educator)

Director of the computer-graphics program at the Pasadena Art Center College of Design, Vibeke Sørensen (not related to the author) teaches a computer-graphics course for graphic designers, industrial designers, and illustrators.

"The concept is to give them access to sophisticated programs that will teach them the fundamentals of two- and three-dimensional computer image generation. We are using software especially designed for this course and written for the school's Atari computers by Jim Blinn and Bob Schaff. The students are not learning programming, they are learning use. Until now, most computer-graphics courses have been in engineering schools because that's where the tools were. As a result, most people in computer graphics tend to be engineers. But computers have been liberated from the domain of the engineers and put in the hands of all kinds of people, including artists, with the advent of the personal computer.

"I believe that you should have an education in the process; you should learn about elementary programming—even if you're an artist. That doesn't mean you're going to be a programmer; it means you should be able to talk to programmers. Whatever industry you want to work in, people want to hire trained people. It's much more expensive to train people on the job, so it makes sense to go to a school where you can learn computer graphics. The question is, what is your background, and what do you want to do?

"The other way to get into the business (if you're not going to go through an organized program or the course doesn't exist) is to beg, borrow, or buy a small computer (an Apple or Atari being the low end) and teach yourself. There are a lot of books and tutorials on how to do it. Basically, it's a question of technique. That's the way to get started and find out if it's for you—because it's not for everybody."

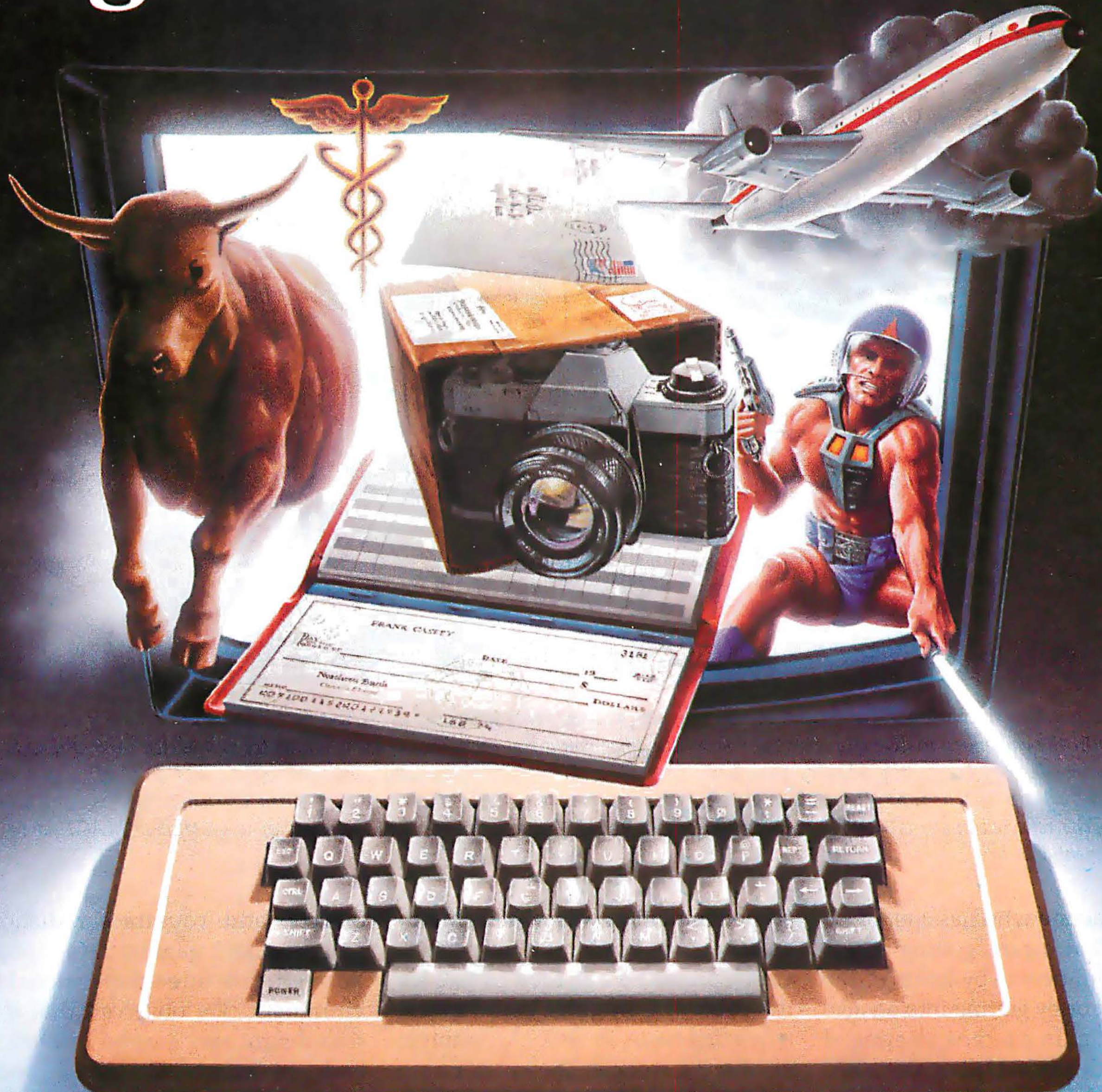
Charles Csuri (Cranston/Csuri)

For over a decade, Charles Csuri has taught computer graphics at Ohio State University. He and his students wrote a lot of highly interactive software that has advanced the state of the art. Recently he formed a company, Cranston/Csuri, that quickly caught everyone's attention for its attractive ray tracing and sophisticated medical imagery. The firm's demo reel won several prizes, including grand prizes at the Tokyo International Computer Animation Competition and the London Competition. Cranston/Csuri is talking with several personal computer manufacturers about putting together a three-dimensional, key-frame animation system. The company currently uses VAXes but is "sticking to our guns and working on a multiprocessor system of our own design."

Csuri, interested in artificial intelligence, said, "I have several excellent graduate students trying to put together an expert system for three-dimensional character animation that will control a figure so that it moves very smoothly. (See photo 1.) There is a lot of exciting discussion going on—what sorts of tasks does an animator do that could be automated in an expert system to facilitate decision making? As far as I am concerned, this is the future of character animation, but the problems are very difficult. The easy problems have been solved, but there are a whole bunch of nasty, difficult things that are still out there."

Csuri advised, "It's really important to have a tutor or mentor, to be

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Photo 11: *Chrome Dog, created by Gene Miller. A new mapping process being developed at MAGI by Miller is dramatically demonstrated here, along with the capability to digitally compose a synthetic image on a real background. First, an object is modeled from ellipsoids, the primitives are blended together using Miller's Fuse Body program and then surrealistically combined with a shot of MAGI's parking lot scanned in video digitizing. Then, to get a wide-angle view of the parking lot, MAGI photographed a silver Christmas tree ball and scanned it in. Finally, the reflected image is mapped onto the object and* voilà!*—instant chrome dog. (The author is grateful to MAGI for the use of this experimental image.)*

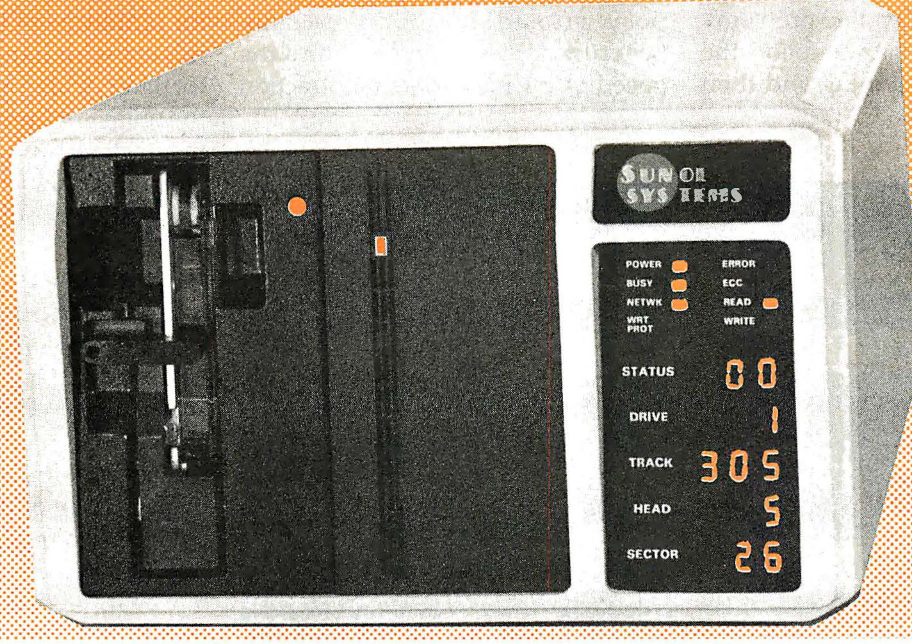
around someone who has a lot of experience. That means getting access to this kind of person by joining a lab or company or by getting into an academic setting. In a recent meeting of 150 college deans in Dallas, we asked who would have jobs for our graduates, and over two-thirds of them raised their hands! It's very clear that there is a need for trained people in the field."

Phillip Mittelman (Mathematical Applications Group Inc./Synthavision)

The first company to do computer scene simulation was MAGI (Mathematical Applications Group Inc.), which produced a shaded picture for the cover of Computer World magazine's first issue, in 1967. (An example of MAGI's work is shown in photo 11.) Actually, MAGI sort of backed into its role as filmmaker because it originally conceived its ray-tracing software programs for civil and governmental studies of nuclear particles and radiation. Dr. Phillip Mittelman, the founder of MAGI, recalled, "'The technique we had developed was one where you describe the world as made of three-dimensional objects, and you trace radiation—neutrons and gamma rays—around through this three-dimensional environment. We observed that if we traced light rays around instead, we had, in effect, simulated photography. That's the basis of our whole idea: you track the light rays and find out what the color and intensity would be at each point on the film. Bob Goldstein was the person who adapted our radiation programs for picture making, working on it alone for a long time. So, MAGI's Synthavision process, which today is very fast and efficient for moviemaking, rests

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"We were totally independent and out of touch with the picture making that was going on at the University of Utah and places like that in the early days. At one time we showed some of our work to some IBM people and they said, 'My gosh, you've solved the hidden line problem!' We were really quite naive. We said, 'What's a hidden line problem?' With ray tracing, since you follow the ray until it hits something and then bounce it off, you don't concern yourself with what's behind that surface. There could be a thousand objects behind it; we didn't care. The first animation we did, probably the first shaded computer animation ever done on a commercial basis, involved three-dimensional lettering for IBM's Office Products Division. That was at least 12 years ago."

MAGI recently got a new computer, a Gould SEL 3287, "a real number cruncher," roughly one-third the speed of a Cray for a small fraction of what a Cray costs. "It's literally eight times faster than the computer we used for *Tron*," said Larry Elin, an art director for 10 years with the company. "We find that we wind up making pictures that are eight times more complicated. It's interesting that when you get a faster computer, you don't make faster pictures—you make better pictures!" MAGI is also working on a system called Synthamation for rapidly combining computer animation with hand-drawn animation for large-scale productions. It gives the animator unprecedented freedom to move around in the scenes and gives the characters an airbrushed, three-dimensional look.

Richard Moszkowski

Having discussed the state of the art with so many movers and shakers in the computer-graphics business, it seems appropriate to wrap up the story with a young man in the trenches. He is a self-described hacker/survivor/dreamer whose talent in programming graphics has led him to some enviable jobs. In just a few years he has gained experience and an excellent overall vision of the field. Richard Moszkowski, a student at UCLA in the late 1970s, started as a progammer for John Whitney Sr. He then worked for some game companies (designing a game built into a watch) and Digital Productions (where he worked around the Cray). Now back to games again, he is designing a light pen and stereo three-dimensional glasses for the Vectrex machine.

A free agent and therefore uncommitted to plugging the virtues of any particular system, Moszkowski was a likely candidate to offer an unbiased assessment of where things are and where they're going.

"One indicator of how things are now is that the equivalent of Ivan Sutherland's Sketchpad program is running on microcomputers. That software marked the beginning of computer graphics for mainframe machines in the 1960s at MIT. On the other hand, we now have the use of supercomputers for motion-picture animation. And this year we have the 32-bit computer-on-a-chip, such as

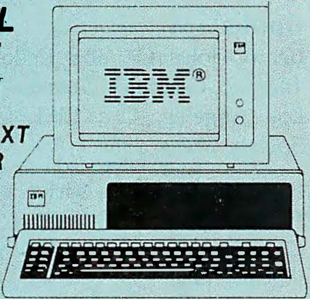
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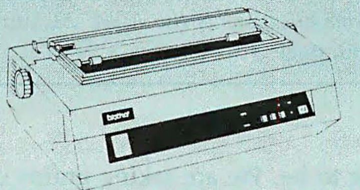
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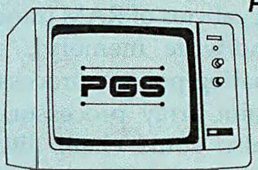
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the 68020. DEC [Digital Equipment Corporation] is coming out with their Micro-VAX, National is introducing their 32032, and there are 256K RAMs coming out. Finally, the Weitek array-processor chip has hit the scene, capable of doing 10 million floating-point instructions per second—for 600 bucks! Weitek is developing what *we* want: supercomputers on VLSI [very-large-scale integration] technology."

"There are two ways that the super graphics machines of the future will be built," Moszkowski said. "One is bigger and faster computers, single-instruction, hundred-megahertz machines. In this case you're limited by the heat dissipation. As you go faster and faster, the heat rises incredibly, and so does the cost. The other, what we're going to witness in the next three or four years, is micrographics engines one-tenth the speed of a Cray, 10-megahertz machines made of off-the-shelf components. They will consist of a 32-bit VLSI chip, about 8 megabytes of RAM [random-access read/write memory], some kind of floating-point coprocessor, a floating-point array processor, and possibly also some cheap little z-buffer. All this will fit onto one or two boards and will cost a few thousand dollars. That's great—a real number-crunching microcomputer as opposed to just a data-processing micro. The next thing they will do is put a couple of these together, and then another and another. Pretty soon there'll be scores of them together in racks. Each of them will process individual frames of film, and working together they'll crank out film faster than a supercomputer. So, when you walk into the room, it will be like walking into the Disney studios where you see a lot of little bald-headed guys with glasses, each doing their own frame, only you'll see rows and rows of little blinking LEDs [light-emitting diodes] instead.

"I grew up on micros, I've seen them grow, and they are really going to take over. When you can put a hundred thousand gates on a single integrated circuit and sell it for under 50 dollars a chip, there's no way to stop it. That's just what the future is going to be. We are taking grains of sand, which are common and cheap, produced with more efficiency than anything in our society. When you start putting them together, they become an entity that is more than the sum of its parts. I don't think the day is too far away when you will be able to make your own computer-animated movies at home."■

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IEEE Computer Graphics and Applications, IEEE Computer Society, 10662 Los Vasqueros Circle, Los Alamitos, CA 90720

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Eurographics Association, POB 199, CH-1211, Geneva 16, Switzerland

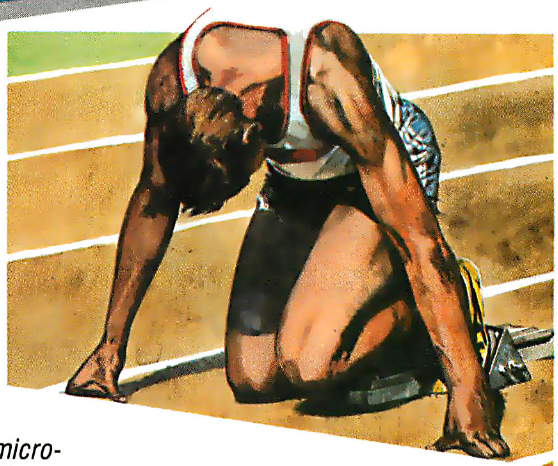
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Peter Sørensen (Second Genesis, 6867-1/2 Fountain Ave., Hollywood, CA 90028) is a freelance author and computer-graphics consultant who has designed and directed special effects for film and video.

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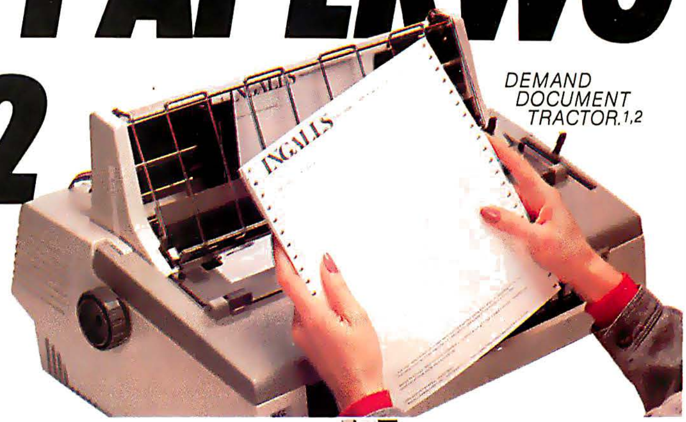
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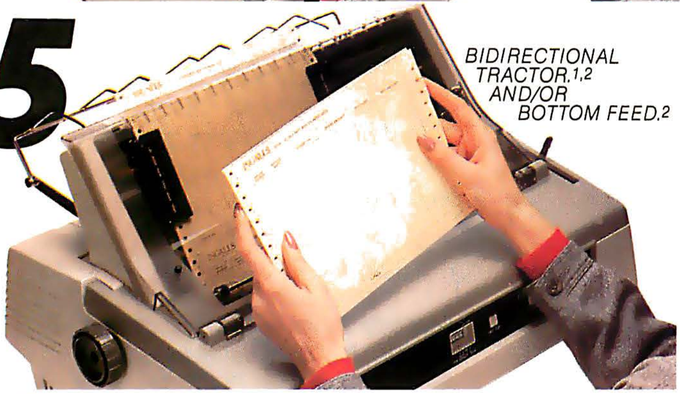
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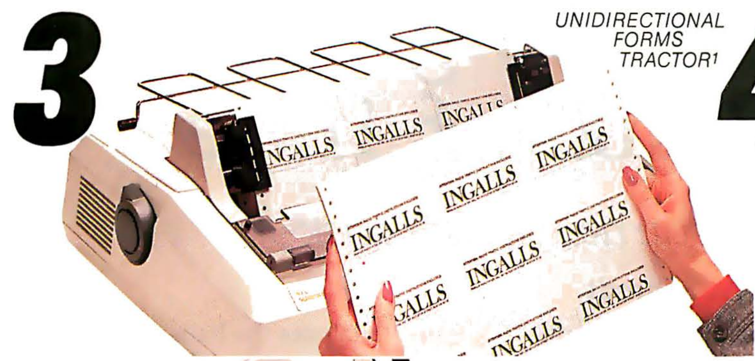
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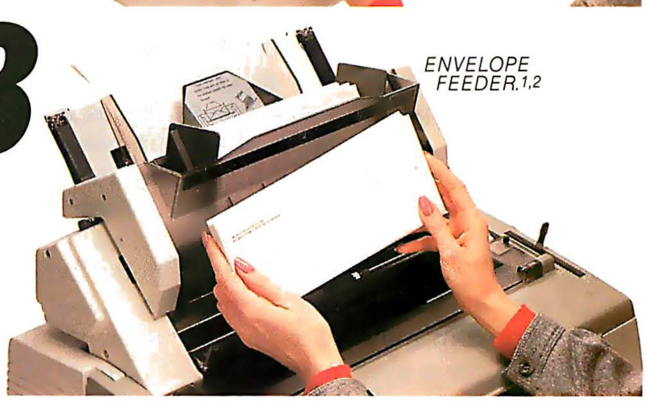
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Simulation of Weighted Voting: The Banzhaf Index

Sometimes the little guy carries the big stick

by Philip A. Schrodt

In this election year it is fascinating to try to determine how major political parties choose their candidates and get them elected. The candidates must please as many people as possible and make involved political deals and trades. The Banzhaf index, an approximation of voting power, explains how the dark horse can end up as the front runner.

Consider the following situation: a parliament containing four parties meets to form a government. The parties control the following votes:

A	225
B	198
C	73
D	42

The party that can assemble a coalition containing a majority of the votes (270) chooses the prime minister. From which party is the prime minister chosen? Looking at party sizes, you would assume party A, with 41 percent of the votes, or possibly B, with 37 percent, because these are considerably larger than the others. In fact, the prime minister comes from party C, with only 14 percent of the votes. Why? Because of coalitions.

There are a total of seven possible coalitions with more than 270 votes: AB, AC, ABC, ABD, ABCD, BC, and BCD. No other coalition has enough votes to form a majority. You can reduce the number of coalitions even further because the partners want to keep the coalition as small as possible. You form coalitions by promising ministerial posts to potential partners. Only a limited number of posts exist, and each party wants to control as many ministries as possible. Therefore, the practical number for a coalition is just enough votes to form a majority, but no more. These are called "minimum winning coalitions," or MWC, a concept developed in detail by William Riker (see reference 3).

The MWC principle reduces the coalitions to AB, AC, and BC. Notice that party D entirely disappears from the calculations. There are no circumstances in which a minimum winning coalition needs to include D, so even with 8 percent of the votes, party D is irrelevant. The remaining parties are equal, despite the disparity of votes, because each one must join another to make a majority. If, in addition, you rule coalition AB out because the two major parties don't want to share power, party C becomes the sole determining party and, therefore, claims the prime minister position. Party C, with only 14 percent of the votes, plays a pivotal position.

This situation is not hypothetical; it is a simplified version of the Italian Chamber of Deputies after the June 1983, election. The large parties are the Christian Democrats (A) and the Italian Communist party (B). Party C is the Socialist party. The prime minister of Italy, Bennito Craxi, is a Socialist.

Table 1 analyzes the Italian Chamber of Deputies with Banzhaf indexes, measuring the proportion of the time a party is pivotal in an MWC. In the 1983 election the two leading parties had roughly 67 percent of the parliamentary votes between them. However, since they were unwilling to form a coalition, they had less than 40 percent of the Banzhaf power. The Socialists had 27 percent of the Banzhaf power even though they had a mere 7 percent of the votes. They used that power to gain the prime minister position. The Banzhaf power is by no means the sole determining factor here, but it provides a better guide than simple vote distribution.

The Banzhaf Index

The Banzhaf index is named after John F. Banzhaf III, who first used it in a study of voting in the Nassau County, New York, legislature. In 1964 this legislature had six members with the following number of votes: 31, 31, 28, 21, 2, and 2. Banzhaf noted that in this situation the members with two votes were essentially powerless. Their votes made no difference whatsoever in the final outcome of the election. Surprisingly, this was also true of the member with 21 votes. You could have a winning majority (58 votes) with the two-member combinations [31,28] and [31,31], but even the four-member combination [31,21,2,2] did not constitute a majority. Therefore, the six-

member legislature was effectively a three-member legislature.

The Banzhaf index is simply the probability that a particular voter or party will be a pivotal member in a winning coalition (when all coalitions are assumed equally probable). A pivotal member is one whose departure can cause the coalition to lose. A member who is not pivotal has little political pull because the other coalition members lose nothing if he or she leaves. The Banzhaf index is one measure of the influence that a member or party has on a legislative body.

If every member has a single vote, then all Banzhaf indexes are equal to $1/n$, where n is the number of votes. The index becomes more interesting in *weighted voting* situations, where members or parties have different numbers of votes.

Weighted voting situations occur in a number of different situations. The most familiar one for political scientists is the multiple-party parliamentary system, like the Italian example above, in which parties must assemble a winning coalition to form a government. In Israel the Likud coalition has a bare majority in parliament; thus, tiny fringe parties in that coalition become pivotal and have substantial power over government policy.

Weighted voting occurs in a variety of other situations, such as corporate stockholders' meetings, where the voting is based on the number of shares owned. A variety of international organizations, including the International Monetary Fund and the European Economic Community, use weighted voting. Even the United Nations Security Council, with its veto power for the five permanent members, can be analyzed with the Banzhaf index. As Riker and Ordeshook (reference 4) show, the five permanent members have 98 percent of the Banzhaf power while the 10 nonpermanent members share the remaining 2 percent.

The electoral college used in presidential elections in the United States is another example of weighted voting. Table 2 gives the Banzhaf power of the various states in determining the outcome of presidential elections. Two things are clear. First, the Banzhaf power does not differ dramatically from the proportional power—as is usually the case when large numbers of voters are involved. Second, the Banzhaf power favors large states over small. This partially compensates for the electoral college itself, which favors small states over large. The Banzhaf power per person in the larger states is more evenly balanced than the proportional power per person.

"Quarreling members" affect the Banzhaf indexes as well. In Italy the two largest parties, the Christian Democrats (DC) and the Communists (PCI), will not enter a coalition together. The small parties of the political center—the Socialists, Republicans, and Liberals—therefore have a disproportionate amount of Banzhaf power, roughly double their proportional power. Italian parliamentary coalitions are extraordinarily unstable because of the impossibility of this DC-PCI partnership.

Italian Chamber of Deputies, June 1983

Party	Votes	Proportion	Banzhaf Index	Banzhaf without DC-PCI Coalitions
Christian Democrats	255	.357	.324	.223
Communist	198	.314	.224	.154
Socialist	73	.116	.224	.270
Italian Social Movement	48	.067	.074	.102
Republican	29	.046	.055	.078
Democratic Socialist	23	.037	.044	.061
Liberal	16	.025	.035	.049
Radical	11	.017	.020	.028
Proletarian Democrats	7	.011	.014	.019
Small regional parties	6	.010	.012	.016

Table 1: *The proportion of time a party is pivotal in an MWC.*

United States Electoral College, 1984

States	Votes	Proportion	Proportion / Population	Banzhaf	Banzhaf / Population
CA	47	.0873	3.69	.0932	3.95
NY	36	.0669	3.82	.0710	4.06
TX	29	.0539	3.78	.0554	3.90
PA	25	.0465	3.90	.0482	4.07
IL	24	.0446	3.91	.0446	3.91
OH	23	.0428	3.95	.0484	4.48
FL	21	.0390	4.02	.0393	4.05
MI	20	.0371	4.03	.0377	4.10
NJ	16	.0297	4.07	.0280	3.83
MA NC	13	.0242	4.15	.0234	4.03
GA IN VA	12	.0223	4.16	.0223	4.16
MO WS TN	11	.0204	4.31	.0201	4.25
LA MD MN WA	10	.0186	4.48	.0177	4.29
AL KY	9	.0167	4.51	.0165	4.46
CO CT IA OK SC	8	.0148	4.90	.0145	4.83
AZ KS MS OR	7	.0130	5.14	.0127	5.03
AR WV	6	.0111	5.28	.0109	5.19
NE NM UT	5	.0093	6.30	.0088	6.03
HI ID ME MT NV NH RI	4	.0074	8.22	.0068	7.55
AK DE DC ND SD VT WY	3	.0056	10.33	.0053	9.77

* Based on 150,000 Monte Carlo experiments. Population ratios are multiplied by 1,000,000,000.

Table 2: *The Banzhaf power of each state in determining the outcome of the 1984 presidential election.*

Even so, the political center prefers to keep these two major parties at odds with each other. Coalitions must be rounded out with an assortment of small parties that control only one or two votes each. This arrangement keeps the small parties in business and gives them their power.

Calculating Banzhaf Indexes

You can calculate Banzhaf indexes in one of two ways. If there are only a few parties, a computer can quickly go through all possible coalitions. For a set of *n* parties, the number of possible coalitions is $2^n - 1$. So, for example, a 10-party system involves calculating only 1023 coalitions.

For a larger system, however, exhaustive calculation becomes impossible. For example, in the 51-state United States electoral college, there are about 2,251,800,000,000,000 possible coalitions. Even at computer speeds, the time required for these calculations is prohibitive. If one coalition could be evaluated each microsecond (and it can't), the computation would require 71 years to complete. That's a bit long to wait for results. Instead, you can obtain approximate results using what is known as Monte Carlo simulation.

In Monte Carlo simulation, a random-number generator sets up coalitions randomly. The system evaluates each coalition first to see if it contains enough votes to win; if so, it determines the pivotal members. After the system generates a large number of random coalitions, the percentage of times a party is pivotal should be roughly equal to its Banzhaf index. I've used this method on systems with as many as 200 voters (presidential nominating conventions). The indexes converge fairly rapidly.

The time it takes to evaluate each coalition is greater for the Monte Carlo method than it is for the exhaustive method. For example, it takes about 1.5 times as long to run 1023 Monte Carlo experiments as it does to compute them exhaustively (53 seconds versus 35 seconds on an Apple II). The additional overhead comes from setting up the coalitions. You may need to experiment to find the most efficient means of evaluation. The 150,000 experiments used to generate table 2 took about six hours, running the Apple II with a "Mill" coprocessor. It took only 30,000 experiments, however, to produce reasonably similar results.

The Program

Running the program (see listing 1) is fairly straightforward. You simply enter the vote data, choose the Monte Carlo or exhaustive method, and then let the program compute the indexes. You may repeat this as often as necessary.

The first prompt in the program asks you whether you want to enter information from a .TEXT file. If you have prepared the vote data beforehand, respond "yes" to this question and give the program the filename; otherwise, enter the data directly from the keyboard.

The input consists of identification information and vote information. Up to 10 lines can identify the file. Terminate this with a "null record"—a line consisting of only a Return

Text continued on page 152

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Listing 1: *A program to compute Banzhaf indexes using either Monte Carlo simulation or an exhaustive evaluation.*

```
PROGRAM BANZDEMO;
(* program for computing Banzhaf indices using Monte-Carlo simulation
   or exhaustive evaluation.
   Apple II Pascal *)
(*$C copyright (C) 1983, Philip A. Schrodt *)

uses applestuff;
     (* Two procedures used from applestuff:
          randomize: randomly set seed of random number generator
          random:    function generating random numbers with a
                       Uniform[0,1] distribution *)

const maxvot=200; (* maximum number of partys allowed *)

var votes: array[1..maxvot] of integer; (*votes by party*)
    ncex,totpivots,nid,np,mwcvote:integer; (* number of coalitions evaluated;
                                    total pivots,number of id lines,
                                    number of parties,votes required for mwc*)
    numpivots: array[1..maxvot] of integer ;(*number of pivots*)
    name: array[1..maxvot] of string; (* party names *)
    id: array[1..10] of string; (* run identification information*)
    mem: array[1..201] of boolean; (*coalition membership*)
                      (* Warning: change 201 to maxvot+1 if maxvot is changed *)
    bi: array[1..maxvot] of real; (* Banzhaf indices*)
    printflag:boolean;
    totvot,nex,kz,ka,kb,npp1: integer;(*  assorted counters *)
    inf,pr: text; (*input file,printer*)
    sta:string;

procedure banzprint;forward;

function answer(S:string):boolean;
(* writes question S and checks for 'Y' answer *)
var C:char;
begin write(S,'? -->');read(C);writeln;
   if C=Chr(27) then Exit(program);
   answer:=((C='Y') or (C='y'))
end;

function iconv(S:string):integer;
(* converts string S into integer, ignoring all chars except numerals,
   and '-'.  No error checking.
   Warning-- this is an extraordinarily forgiving integer input procedure...*)
var i,p,k:integer;
    neg:boolean;
begin
  i:=0;neg:=false;
  for k:=1 to Length(S) do begin
     p:=ord(S[k]);
     if (p<58) and (p>47) then i:=i*10 + (p-48)
                         else if p=45 then neg:=true;
     end;
  if neg then iconv:= -i else iconv:=i;
end;

procedure sortfile;
(* bubble sort 'name' and 'votes' by votes *)
var ka,kb,kc:integer;
    sta:string;
begin
  write('Sorting data');
  for ka:=1 to np-1 do begin
```

Listing 1 continued on page 144

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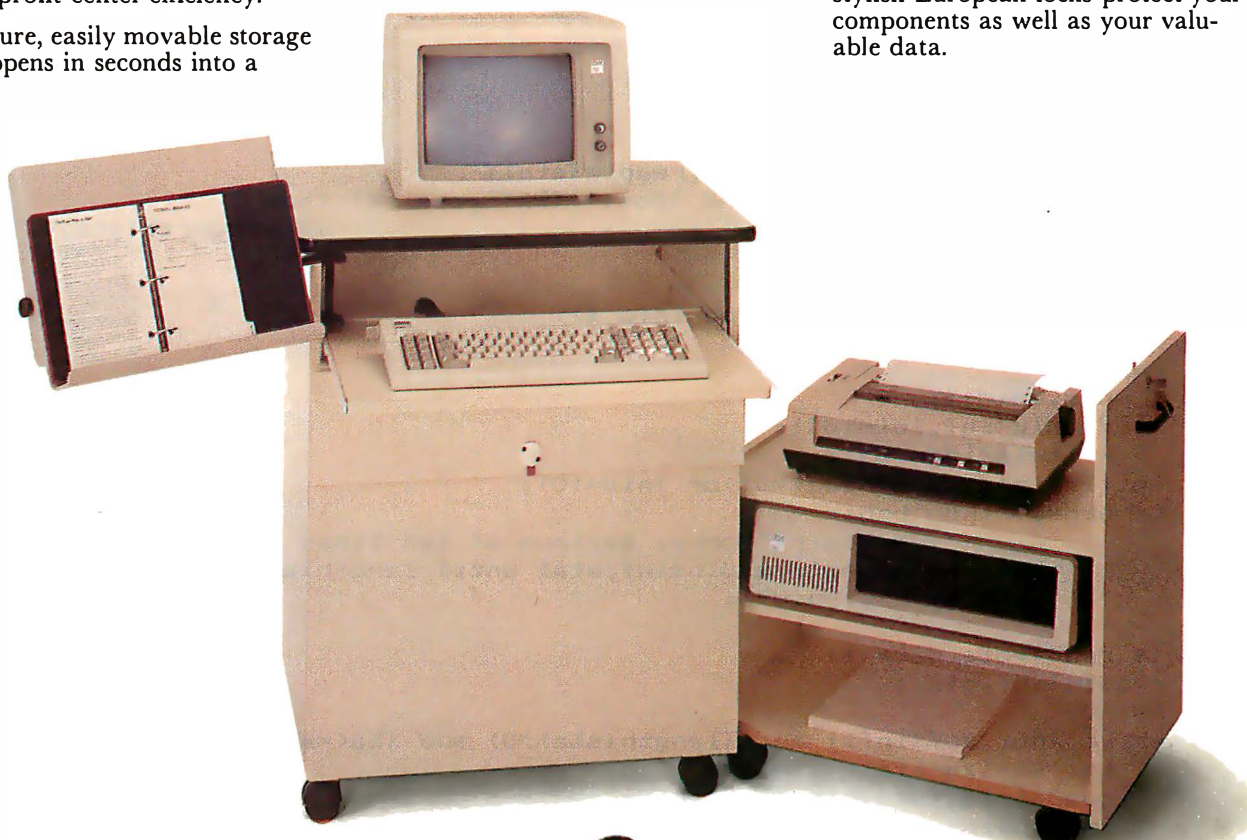
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Listing 1 continued:

```
       write('.');
       for kb:=ka to np do
               if votes[kb]>votes[ka] then
                    begin sta:=name[ka];name[ka]:=name[kb];name[kb]:=sta;
                          kc:=votes[ka];votes[ka]:=votes[kb];votes[kb]:=kc;end;
  end;
  writeln;
end;

procedure readstring(s:string;var n:string;var v:integer);
(* breaks out the party name and votes from input string *)
var ka:integer;
begin
  ka:=pos(':',s);
  if ka=0 then begin n:='error';v:=0;
                     exit(readstring);end;
  n:=copy(s,1,ka-1);
  if ka=length(s) then v:=0
                  else v:=iconv(copy(s,ka+1,length(s)-ka));
end;

procedure readdata;
(*read vote data *)
var ka,kb:integer;
    sta:string;

   procedure readfile;
   (* read from a file *)
   begin
     write('Enter file name-->');readln(sta);
     if (pos('.text',sta)=0) and (pos('.TEXT',sta)=0) then
                                                     sta:=concat(sta,'.TEXT');
     reset(inf,sta);

     (* read file identification info *)
     nid:=0;
     repeat
        nid:=nid+1;
        readln(inf,id[nid]);
        writeln(id[nid]);
     until  (length(id[nid])=0) or (nid=10);
     if nid=10 then begin
                      writeln('Sorry, maximum of ten lines allowed...');
                      repeat readln(inf,sta) until length(sta)=0;end
               else nid:=nid-1;

     (* read vote data *)
     readln(inf,sta);
     ka:=0;
     while (not eof(inf)) and (length(sta)>0) and (ka<=maxvot) do begin
        ka:=ka+1;writeln(sta);
        readstring(sta,name[ka],votes[ka]);
        readln(inf,sta);
        end;
     if ka>=maxvot then writeln('Read stopped at ',maxvot,' parties');
     close(inf);
   end;

 procedure read2;
   (* tail-end of READDATA procedure, which is otherwise too long *)
   begin
     nex:=0;
     for ka:=1 to np do nex:=nex+votes[ka];
```

Listing 1 continued on page 146

```
    writeln('Total votes entered: ',nex);
    write('Enter number of votes of minimum winning coalition:');
    readln(mwcvote);
    sortfile;
end;
begin
   if answer('Is vote data on a .TEXT file')
      then readfile
      else begin (* read from keyboard *)
           writeln('Enter identification info (null to stop):');
                nid:=0;
                repeat
                  nid:=nid+1;
                  readln(id[nid])
                until (length(id[nid])=0) or (nid=10);
           if nid=10 then writeln('Sorry, maximum of ten lines allowed...')
                     else nid:=nid-1;
           writeln('Enter party id and number of votes separated');
           writeln('   by : for each party; null record to finish');
           ka:=0;
           repeat
             readln(sta);
             if length(sta)>0 then begin
                             ka:=ka+1;
                             readstring(sta,name[ka],votes[ka]);
                             if votes[ka]<0 then begin
                                ka:=ka-2;
                                writeln('Backspace -- next entry will replace');
                                writeln('                  ',name[ka],' : ',votes[ka]);
                                end;
                             end;
           until (length(sta)=0) or (ka=maxvot);
           if ka=maxvot then writeln('Maximum of ',maxvot,' parties allowed');
           end;
   np:=ka; npp1:=np+1;
   read2;
end;

procedure init; (* initializes assorted parameters *)
begin randomize;
      for ka:=1 to maxvot do numpivots[ka]:=0;
end;

procedure randcoal;
(* creates a random coalition and counts pivots*)
var pr,ka:integer;
begin pr:=random;
      for ka:=1 to np do mem[ka]:=(random<pr);
end;

procedure allcoal;
(* this increments the mem array to get the next coalition.
   Cycles through all coalitions by treating 'mem' as though it were
   a sequence of binary numbers 1 to 2^np -- "allcoal" in effect does
   a binary add of "1" to "mem" *)
var ka:integer;
begin ka:=1; mem[ka]:=(not mem[ka]);
      while not mem[ka] do begin
          ka:=ka+1;
          mem[ka]:=(not mem[ka]);end;
end;

procedure countpivot;
(* determines the pivotal members in the current coalition
```

Listing 1 continued on page 148

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```
   and increments numpivot array *)
var totvot,ka:integer;
begin totvot:=0;
  for ka:=1 to np do if mem[ka] then totvot:=totvot+votes[ka];
  if totvot>= mwcvote
   then begin
        for ka:=1 to np do
            if mem[ka] then if (totvot-votes[ka]) < mwcvote
              then numpivots[ka]:=numpivots[ka]+1
              else ka:=np;    (*note: this shortcut assumes sorted votes...*)
      end;
end;

procedure exhaust;
(* evaluation of Banzhaf indices by computing all coalitions *)
var ka:integer;
begin ncex:=0;
   for ka:=1 to npp1 do mem[ka]:=false;
   repeat ncex:=ncex+1;
          allcoal;
          countpivots;
          if (ncex mod 20)=0 then write('.');
   until mem[npp1];
     (* stop when np+1 element of mem is 'true' *)
end;

procedure randcomp;
(* evaluates Banzhaf indices using Monte-Carlo methods *)
var ka:integer;
begin
  write('Enter number of random coalitions to generate:');
  readln(sta);
  nex:=iconv(sta);
  writeln('A "." is printed for each 20 coalitions');
  for ka:=1 to nex do begin
                     randcoal;
                     countpivots;
                     if (ka mod 20)=0 then begin write('.');
                                           if (ka mod 500)=0 then
                                                 writeln('Total coalitions:',ka);
                                           end;
   end;
   ncex:=nex;
end;

procedure banzcomp;
(* computes Banzhaf indices*)
var ka:integer;
begin
  totpivots:=0;
  for ka:=1 to np do totpivots:=totpivots+numpivots[ka];
  if totpivots=0 then begin
                     writeln('Error -- no pivots recorded');
                     exit(banzprint);end;
  for ka:=1 to np do bi[ka]:=numpivots[ka]/totpivots;
end;

procedure print(st:string);
begin
   writeln(st);
   if printflag then writeln(pr,st);
end;
```

Listing 1 continued on page 150

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Listing 1 continued:

```
procedure banzprint;
(* computes and prints results *)
var ka:integer;
    sta,stb,sty:string;

  procedure printres;(* prints individual results *)
  var rato,dif,prop:real;
  begin
    for ka:=1 to np do begin
      prop:=votes[ka]/totvot;dif:=bi[ka]-prop;rato:=bi[ka]/prop;
      stb:=copy(concat(name[ka],'           '),1,10);
      write(stb,'  ',votes[ka]:5,'  ',prop:8:5,'  ',bi[ka]:8:5);
      writeln('    ',dif:8:5,'  ',rato:8:5,'     ',stb);
      if (not printflag) and ((ka mod 20)=0) then begin
         writeln('                  <PRESS RETURN>');
         readln(sta);
         writeln(sty);end;
      if printflag then begin
                write(pr,stb,'  ',votes[ka]:5,'  ',prop:8:5,'  ',bi[ka]:8:5);
                writeln(pr,'    ',dif:8:5,'  ',rato:8:5,'     ',stb);end;
      end;
  end;

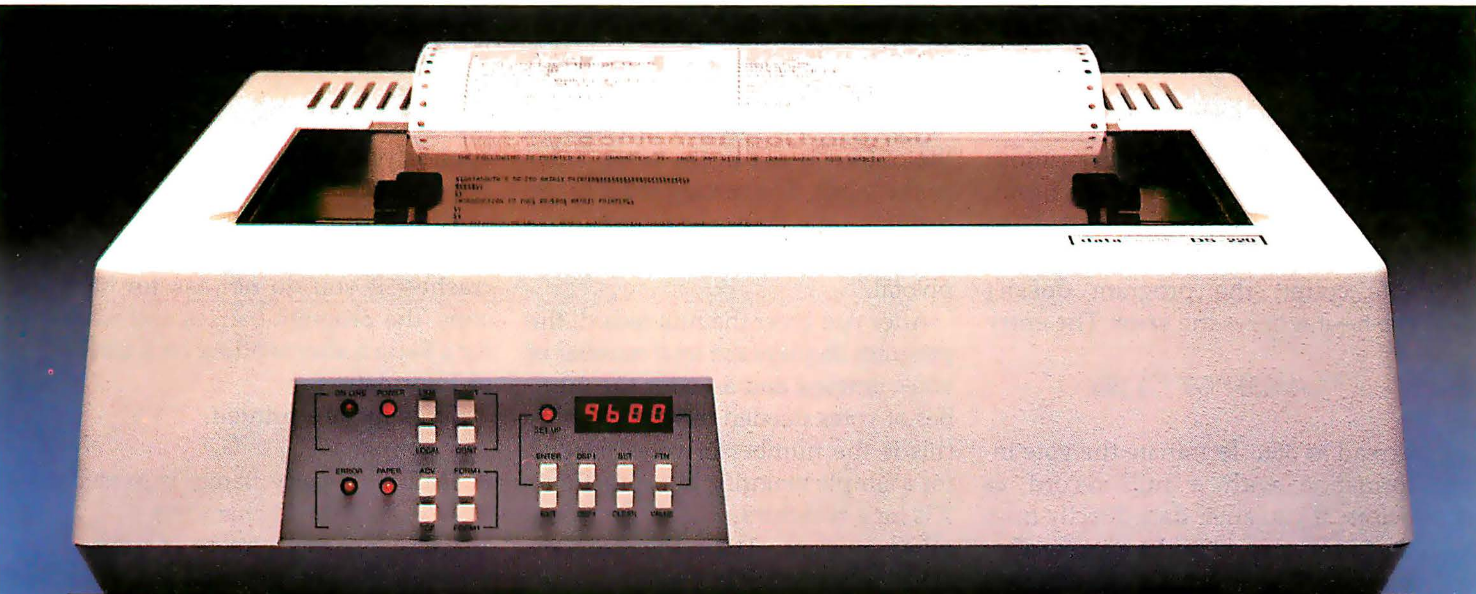
begin
  writeln;
  printflag:=answer('Do you want hard copy');
  if printflag then rewrite(pr,'printer:');
  print(' ');
  for ka:=1 to nid do print(id[ka]);
  print(' ');
  str(mwcvote,sta);
  print(concat('Votes for minimum winning coalition= ',sta));
  str(ncex,sta);
  print(concat('Total Experiments= ',sta));
  banzcomp;
  str(totpivots,sta);
  print(concat('Total Pivots= ',sta));
  print('  ');
  totvot:=0;for ka:=1 to np do totvot:=totvot+votes[ka];
  sty:='NAME        VOTES    PROP VT    BANZHAF       DIFF       RATIO        NAME';
  print(sty);
  printres;
  if printflag then close(pr);
end;

(* main program *)
begin
write(chr(12));  (* clear screen *)
writeln('       BANZHAF INDEX DEMONSTRATION PROGRAM');
writeln('            (c) 1983, Philip A. Schrodt');
writeln;

repeat
  init;
  readdata;
  writeln;
    writeln('Enter Y for exhaustive evaluation,');
  if answer('       N for Monte-Carlo evaluation') then exhaust else randcomp;
  banzprint;
  writeln;
until (not answer('Do you wish to compute additional indices'))
end.
```

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Text continued from page 140:
(read as a string of length zero).

The vote input consists of a party name and the appropriate number of votes separated by a colon (:). For example,

Communist:	290
Republican:	40
Liberal:	30
Christian Democrats:	320

The system truncates names to 10 characters in the final index printout but they may be any length on input. The vote entry is "bullet-proofed," so if you accidentally enter a letter in the vote count, the program doesn't crash—it ignores the error. The entry

#$%3$#%5' '") ($6

is read as 356. Terminate the vote information with a null record as before. If you enter data directly from the keyboard and find a mistake after pressing Return, enter a negative vote in the next entry to void the error. Then you can retype the previous entry. For example,

Liberal:	35
X:	– 1
Liberal:	30

changes the Liberal entry to 30 votes.

You may enter a maximum of 200 parties. You can probably expand this by increasing the dimensions in the program's array declarations, but 200 is close to the maximum possible on an Apple II. The system sorts the parties by the total number of votes, so the output is not in the same order as the input. The sorting reduces the running time by not evaluating parties without enough votes to be pivotal.

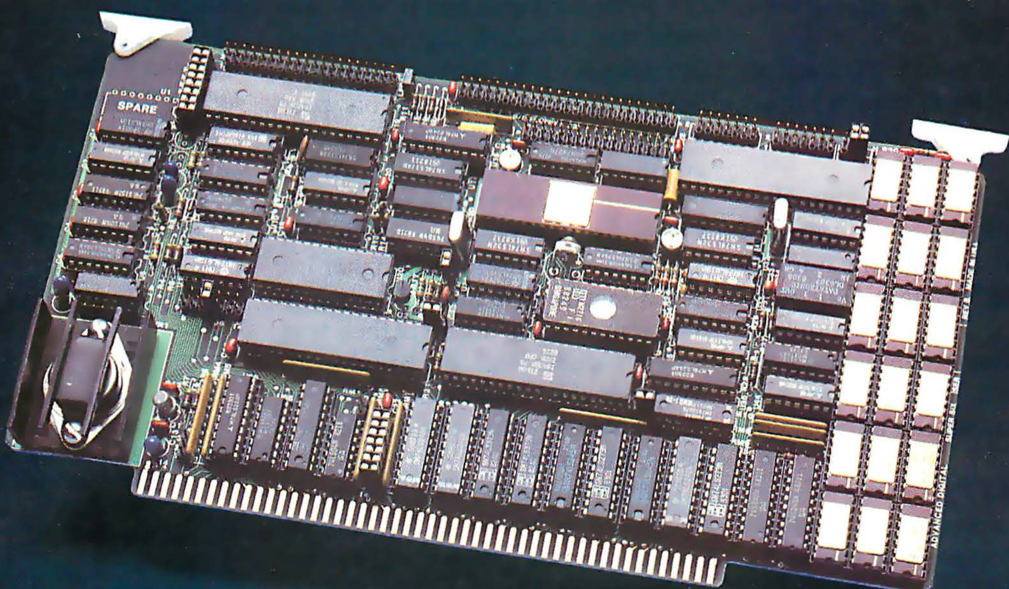
After you enter the null record, the program displays the total number of votes entered and asks for the number of votes needed to win. Usually, this is the number of votes needed for a simple majority, but sometimes it is for a two-thirds majority or some other amount. Then the program asks you whether you want to evaluate the coalitions with the exhaustive method or the Monte Carlo method. If you choose the latter, it asks you how many random coalitions to generate. This number depends on how patient you are but should probably be at least 1000. On the Apple II 32,767 is the maximum. In either mode, the system prints a period after it evaluates every 20 coalitions so you can tell if the program is still running.

After evaluating the indexes, the program prints the results. It first asks if you want hard copy. If you respond "yes" to this prompt, the output is routed to both a printer and the screen. If you ask for hard copy and don't have a printer, the program crashes. If you do not ask for hard copy, the program pauses and waits for a Return after sending each screen of information.

Six items are printed:

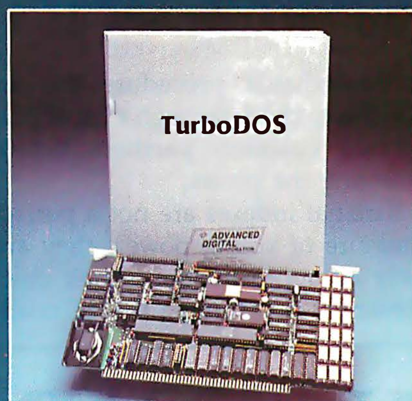
NAME	party name, truncated to 10 characters
VOTES	the number of votes for the party
PROP VT	the *proportion* of the total vote that this party has

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BANZHAF — the Banzhaf index
DIFF — the difference between the Banzhaf index and the proportion of votes (B-P)
RATIO — the ratio of the Banzhaf index to the proportion of votes (B/P)

The system also prints file-identification information, the total number of coalitions evaluated, and the number of votes needed for a minimum winning coalition. It formats the output for an 80-column screen; if you have only 40 columns, press control-A to get the DIFF and RATIO information.

Final Remarks

I have not included any procedures for leaving out impossible coalitions, but they are easy to add. For example, to run the Italian system without the DC-PCI coalition, simply change "countpivots;" to

```
if not (mem[1] and mem[2])
    then countpivots;
```

in the "exhaust" procedure. You can use this to check through a list of prohibited coalition partners before counting the pivots.

Banzhaf indexes are not a perfect measure of voting power; they are only an approximation. Their chief weakness is assuming that all coalitions are equally probable. In reality, coalitions are more likely to form along ideological lines. (The indexes can be recomputed easily with this restriction.) Second, the Banzhaf index does not take into account political maneuvering based on past favors or future promises among potential coalition partners. A skilled politician can have influence despite a weak Banzhaf position. Finally, the difficulty in computing Banzhaf indexes means that most negotiators have only a vague notion of their true power. Nevertheless, the Banzhaf index probably measures influence more accurately than the simple proportion of votes.

The upcoming presidential nominating conventions in the United States provide opportunities for parliamentary-style weighted voting, though this has not happened for a number of years. But if, for example, the Democratic party is unable to nominate a candidate on the first ballot, and if the various candidates can keep their delegates under control, then some interesting bargaining could occur to assemble a winning coalition. Jesse Jackson could easily be in a pivotal position. As these various examples illustrate, it is not the individual number of votes but the number of pivots that is important. It is misleading to look at vote totals alone. The use of Banzhaf indexes casts a light on political power that makes the unexpected a little less of a surprise. ■

Philip A. Schrodt (Dept. of Political Science, Northwestern University, Evanston, IL 60201) is an associate professor in the political science department at Northwestern University. He also teaches mathematical methods in the social sciences program. His book, Microcomputer Methods in Social Science Research, *has just been published by Sage Publications. Dr. Schrodt, who holds an M.A. in mathematics and a Ph.D. in political science, is the originator of the generic word-processor concept (April 1982 BYTE).*

REFERENCES

1. Brams, Steven J. *Paradoxes in Politics.* New York: Free Press, 1976.
2. Brams, Steven J. *Game Theory and Politics.* New York: Free Press, 1975.
3. Riker, William H. *The Theory of Political Coalitions.* New Haven, CT: Yale University Press, 1962.
4. Riker, William H., and Peter C. Ordeshook. *An Introduction to Positive Political Theory.* Englewood Cliffs, NJ: Prentice-Hall, 1973.

Program Availability

The program in listing 1 is available as part of a set of three mathematical political science programs. The other two programs cover the Richardson arms race model (July 1982 BYTE, page 108) and alternative voting methods. The set is available for $25 postpaid in either Apple or IBM format and includes additional documentation. It is available from the author at Polymath Associates Software, Route 1, Box 380, Clinton, NY 13323.

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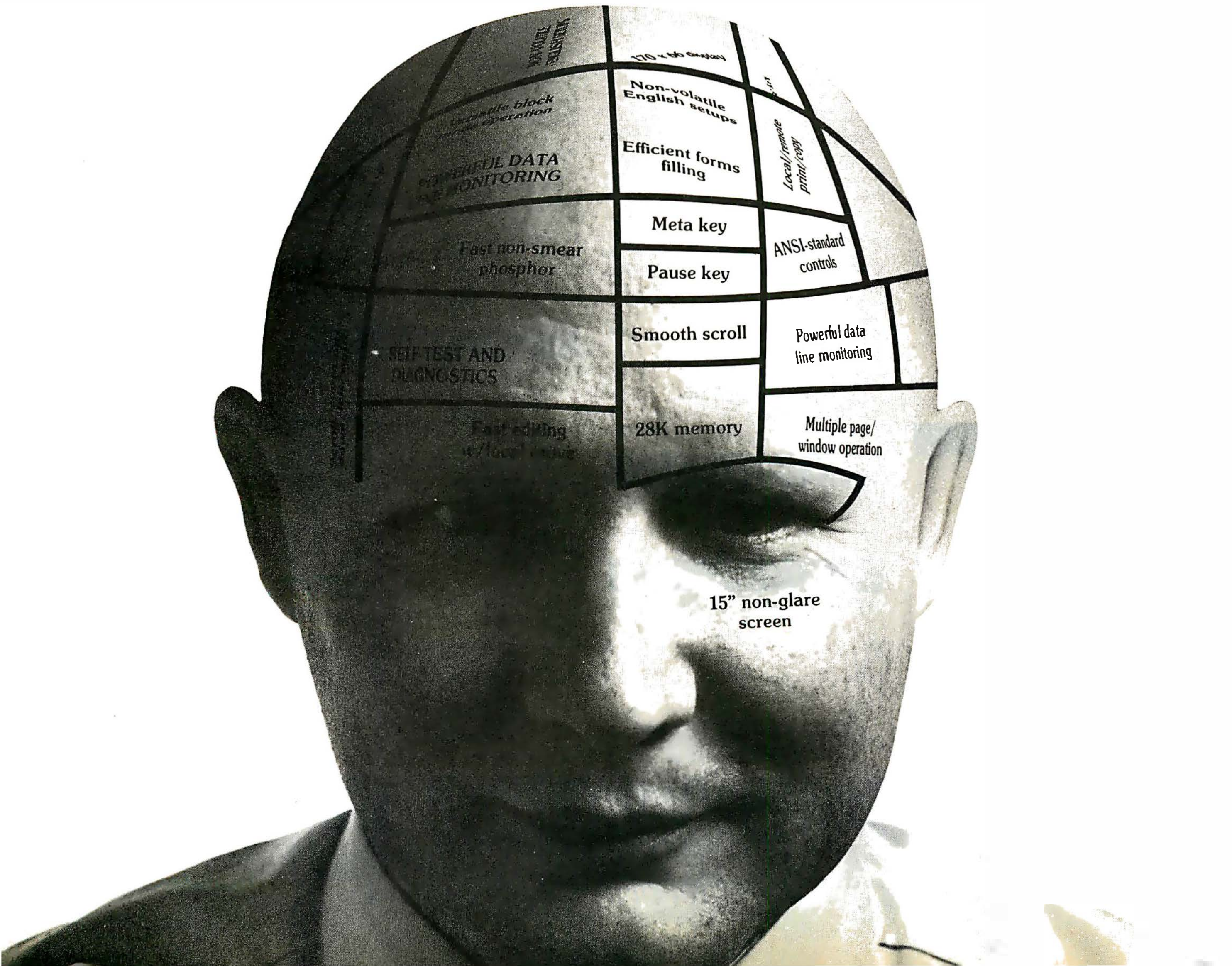
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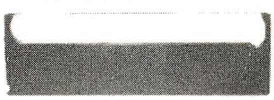
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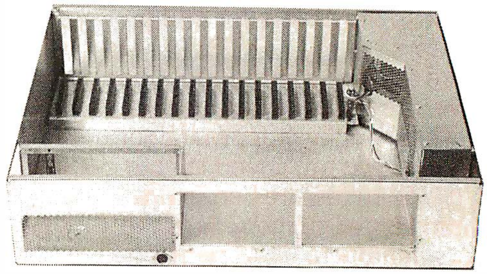
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Queue Simulation

A microcomputer can help you manage waiting lines

by E. Hart Rasmussen

When we wait at the supermarket checkout counter, are stuck in rush-hour traffic, or have trouble getting a telephone call through, we are in a *queue*. Queue is another word for "waiting line." If we could get a firm handle on how queues work, we would be able to manage them better and perhaps even eliminate them.

Simple waiting lines can be analyzed mathematically, but most queuing situations are so complex that they defy precise description. For these situations, a computer can help us. Specifically, we can use a computer to model and simulate a queuing situation so that we can make predictions about it and learn how it behaves.

There are many sophisticated commercial queue-simulation programs available, but they are expensive and for large computers only. In this article, I present an Applesoft BASIC program that can simulate many queuing problems.

Know Your Ps and Qs (Probabilities and Queues)

My doctor's nurse knows that the average examination takes 17 minutes, so she schedules three patients an hour, one every 20 minutes. At first glance, it looks as if I should never have to wait for the doctor. In reality, he needs a sizable waiting room. Why? Because examinations may take more time than expected, and patients don't always arrive on time.

A queue formation occurs when a unit that seeks a service must wait because the service facility is busy servicing another unit. To simulate a queue formation, we need to break it into its basic components.

The basic components are: the arrival of units seeking service, the interval between arrivals, the number of service facilities, and the rate at which the service facilities operate. Figure 1 illustrates some basic ways in which service facilities, or stations, and units may be combined.

We next need to make some assumptions about these components. For instance, we must assume that the overall capacity of the service facility exceeds the overall demand. (In queue terminology, we say that the mean service rate exceeds the mean arrival rate for a single channel.) If we didn't assume this, our queue would theoretically grow to infinite size. We also assume that the intervals between arrivals and service times are variable. To study the queue, we must be able to describe these patterns of arrivals and service times, even if they seem to be unpredictable. Research has shown that the patterns of arrivals and service times often are completely random and can be described with the Poisson distribution. The formula for the Poisson distribution is shown in figure 2. With this formula, we can easily program the random element that we need in our simulation.

Queues of the type shown in parts a and b of figure 1 (that is, with service provided on a first-come, first-served basis with Poisson distribution for an infinite number of arrivals and services) can be described by the mathematics shown in table 1.

The Program

The flowchart in figure 3 shows the logic of a program that simulates a multichannel, single-phase service problem. The Advance module provides the executive control that keeps track of time and events; it passes control to the appropriate action module as successive events are simulated. In the Arrival module, as one arrival occurs, the time for the next arrival is calculated in accordance with the specified algorithm. The arriving unit then joins the queue if all service stations are occupied, or it moves on to seize an available station. The Departure

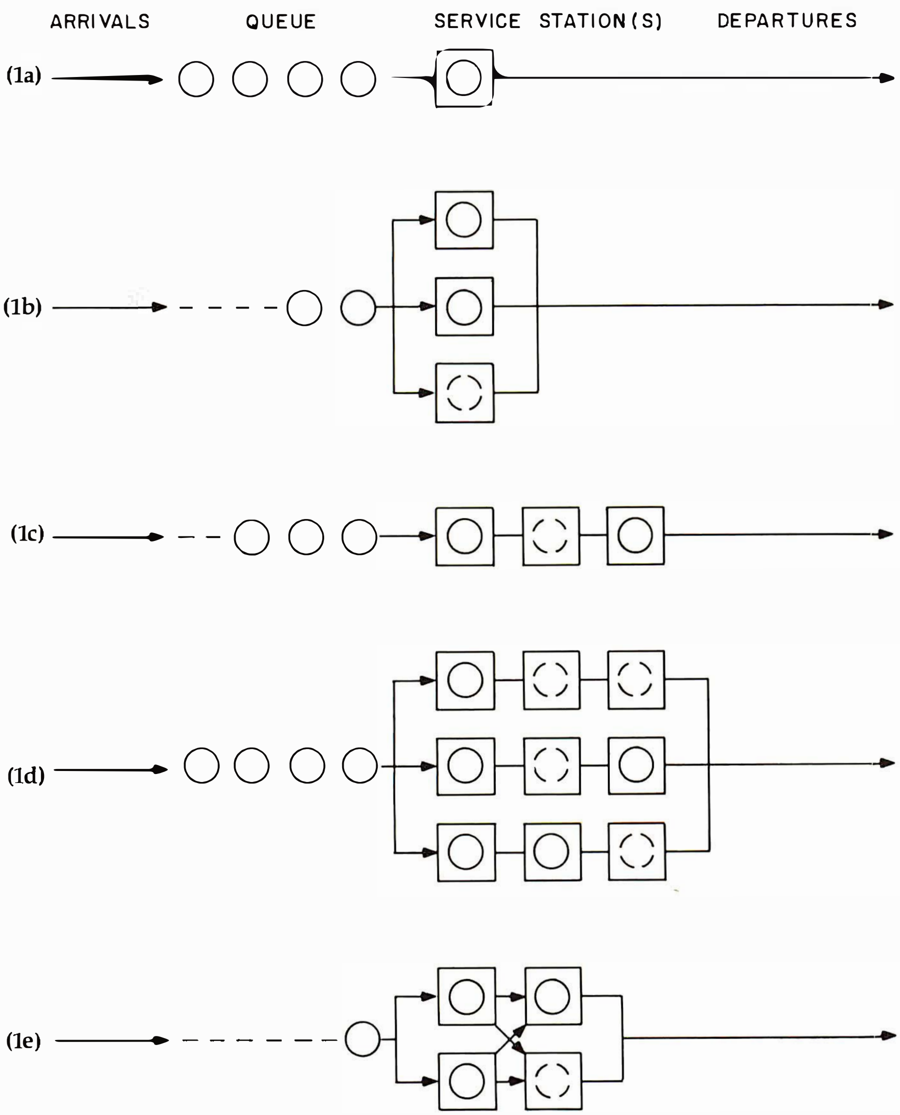


Figure 1: *Fundamental queuing models: (1a) single-channel, single-phase service; (1b) multiple-channel, single-phase service; (1c) single-channel, multiple-phase service; (1d) multiple-channel, multiple-phase service; and (1e) channel switching. The first two models are simulated by the author's program. The broken circles indicate an open service station.*

module frees a station when the service is completed and terminates the simulation if the sample size has been reached. Otherwise, it checks to see if any units are waiting in the queue and, if so, lets a unit leave the waiting line. The Seize module seizes an available service station and calculates the service time in accordance with the prescribed algorithm.

Listing 1 shows the Applesoft BASIC queue-simulation program. The listing is grouped in sections that correspond to the flowchart in figure 3. All variable names used in the program are listed in table 2.

I have defined the frequently used variables at the start of the program. I've dimensioned the arrays to allow 10 service stations, but they can easily be changed to accommodate a larger number. The opening screen and data input (lines 7000–7999) and the start of the simulation (lines 8000–8799) are at the end of the program so the sections of the program that are executed over and over can have the lowest possible line numbers.

The keyboard is used to input data. The only exception is the data for non-Poisson distributions, which is input through DATA statements.

The times for the first arrival and the departure times for any units in a service station are calculated in lines 8000–8799. Depending upon the instructions given during data input, the program uses either a Poisson distribution or a user-defined probability distribution. Arrival intervals and service times can have different distributions, and the random-number generator is used to calculate the randomly varied event intervals in accordance with the specified distributions.

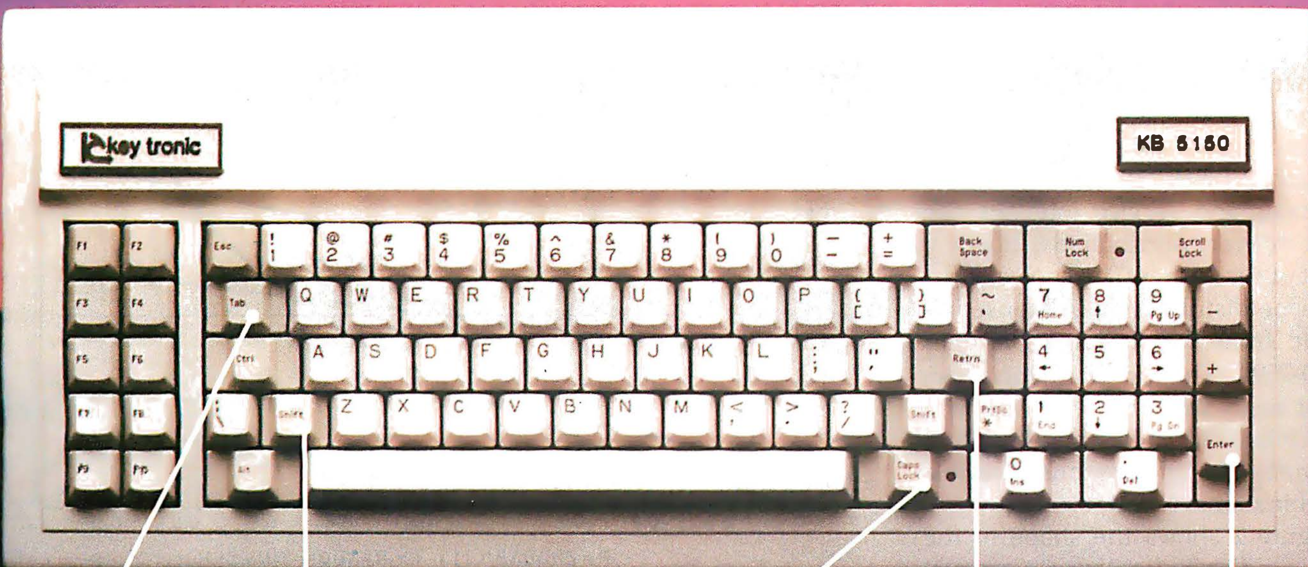
The Advance module determines the earliest event by first assuming that the event is an arrival (line 2000) and then checking if any departure occurs earlier (lines 2100–2130). The clock is then advanced to the earliest event (line 2300). Counters necessary to the calculation of queue statistics are incremented (lines 2310–2420), and control passes to the appropriate event module.

The Arrival module counts the total number of arrivals (line 3000) and calculates the time of the next arrival (lines 3050–3130). If no station is open, the queue length is incremented by line 3230 and the program checks to see if the new queue length exceeds the previous maximum (line 3240).

The Departure module frees the station (line 4000), increments counters (lines 4010–4050), and checks to see if the sample size has been reached (line 4100). If the simulation has not been completed, a unit waiting in the queue (if any) is allowed to seize the free station. The Seize module sets the key that indicates a particular station is in use (line 4250) and then calculates the departure time from that station (lines 4300–4430).

When the sample size has been reached, the program leaves the simulation loop at line 4100 and passes to the section that calculates the statistics for the simulation (lines 5000–5199). After the calculations are completed, the user is given a choice (lines 5200–5399) of sending output to the screen or to a printer. If screen output (lines 5700–5999) is chosen, the user gets a second opportunity to get a printed report (lines 5400–5699). If any non-Poisson distributions have been used, that fact and the parameters for the distributions(s) are recorded on the report (lines 6500–

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6999). When the printing is completed, control is passed back to screen output (line 5690) and the user is given an opportunity to run additional simulations without restarting the program (lines 6000–6499).

The program length is about 7000 characters; it uses a total of about 8200 bytes of memory during execution. The run-time depends somewhat on the type of probability distribution (it runs faster when the formularized Poisson distribution is used). On my Franklin 1000, one simulation takes from 0.33 to 0.47 second, which means that a 2000-sample simulation takes 10 to 15 minutes.

User-Defined Probability Distributions

The program can evaluate queuing situations with unique, user-defined probability distributions. The arrival intervals and service intervals can have different distributions, independent of each other. The choice of the type of distribution to be used is made from the keyboard in lines 7200–7599. The program logic can most easily be explained by table 3, which lists the values that the key P assumes for the various possible combinations.

Figure 2 shows the shape of the Poisson distribution curve (curve 1) and two arbitrary, user-defined curves. The distribution of curve 2 was used in the simulations reported in parts e and f of figure 4. The user must input this nonstandard distribution via DATA statements starting at line 9000. The DATA statements provide the coordinates for the line segments that represent the special distribution. As an example, the distribution shown as curve 3 should be input as follows:

```
9000DATA0,.25,.1,.25,.35,.5,.65,1.5,
.9,1.75,1,1.75
```

If arrival and service intervals have identical, non-Poisson distributions, we define the interval only once. If they have different, non-Poisson distributions, the definition of the arrival-interval distribution precedes the definition of the service-time distribution. For example,

Text continued on page 168

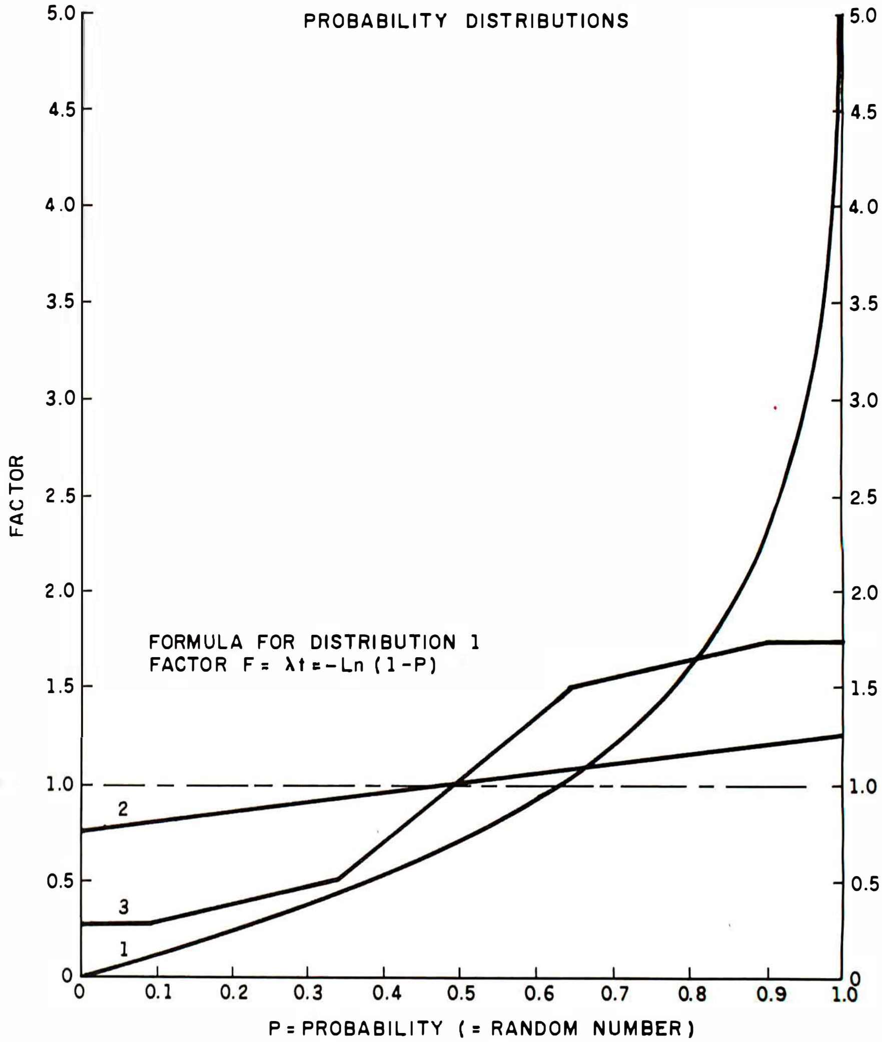


Figure 2: *Probability distributions. Curve 1 shows the Poisson probability distribution. Curves 2 and 3 are arbitrary distributions that can replace the Poisson distribution.*

Queue Component	Variable: Theory	Variable: Program	Equation: One S	Equation: Multiple S
Mean arrival rate	λ			
Mean service rate	μ			
Mean arrival interval	$\frac{1}{\lambda}$	AI		
Mean service time	$\frac{1}{\mu}$	SI		
Number of stations	S	S%	1	S
Utilization factor	U	US(Z)	$\frac{\lambda}{\mu}$	$\frac{\lambda}{\mu}$
Average length of queue	L_q	QA	$\frac{U^2}{1-U}$	$\frac{U^{(S+1)}}{(S-1)!(S-U)^2} \times \frac{1}{\left(\sum_{n=0}^{S-1}\frac{U^n}{n!}\right)+\frac{U^S}{S!(1-U/S)}}$
Average waiting time in queue	w_q	Q1	$\frac{L_q}{\lambda}$	$\frac{L_q}{\lambda}$

Table 1: *Queuing theory variables and equations. S! and n! are the factorial values of these variables.*

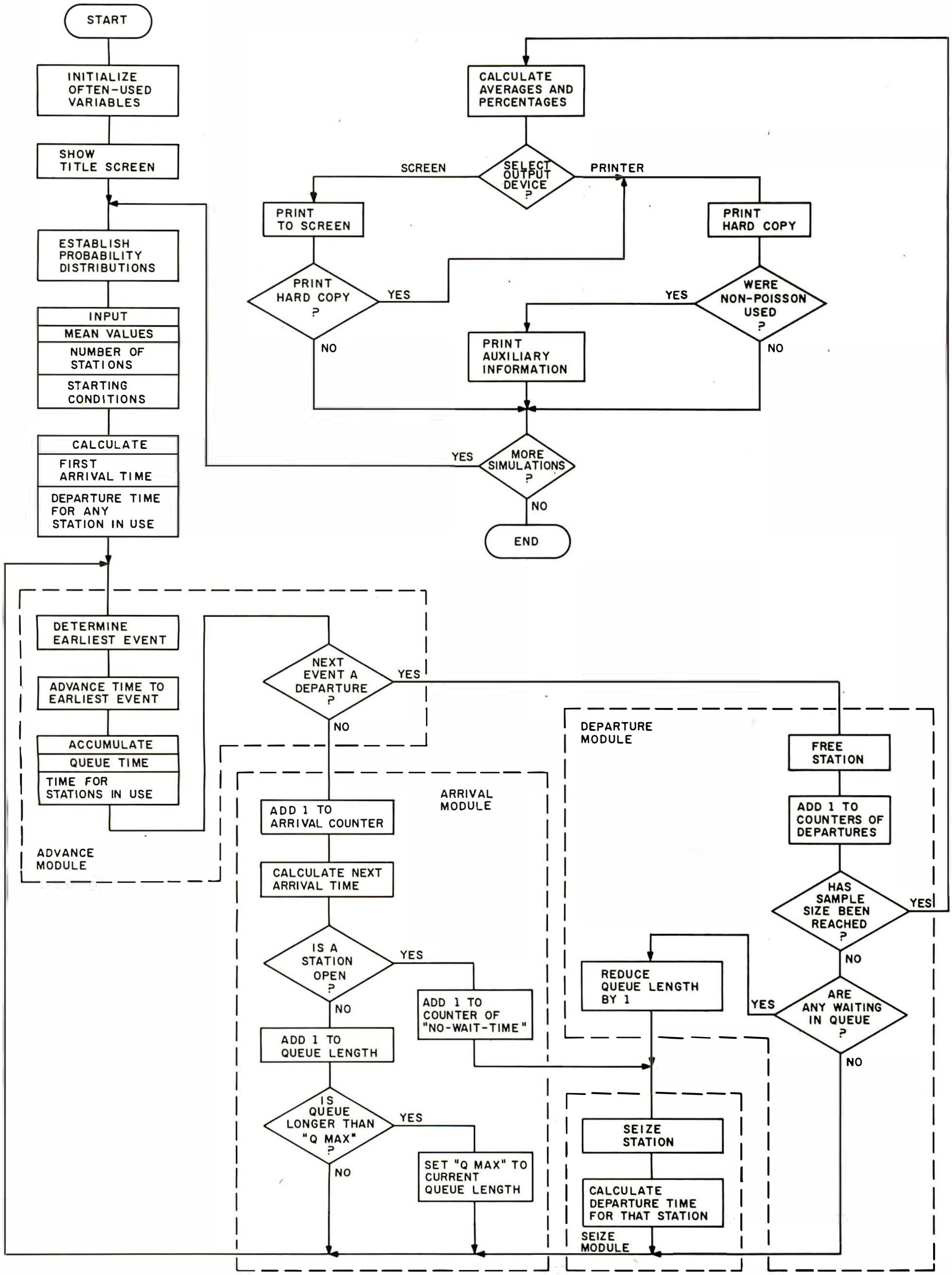


Figure 3: *A flowchart for the author's queue-simulation program.*

Listing 1: *A program, written in Applesoft BASIC, for queue simulation.*

```
                              QUEUE SIMULATION

]LISTO,1999                   START

1000  DIM FA(25,2),FS(25,2),TD(10),S%(10),ST(10),CS%(10)
1010 R = 0:Z = 0:A = 0:TA = 0:S% = 0:T = 0:QL% = 0:C1% = 0:C2% = 0
1020  ONERR  GOTO 8800
1100  GOTO 7000

]LIST2000,2999                ADVANCE MODULE

2000 A = TA - T:N = 0
2100  FOR Z = 1 TO S%
2110  IF S%(Z) = 0 THEN 2130
2120  IF A >  = TD(Z) - T THEN A = TD(Z) - T:N = 1:S = Z
2130  NEXT
2300 T = T + A
2310 QT = QT + QL% * A
2400  FOR Z = 1 TO S%
2410  IF S%(Z) = 1 THEN ST(Z) = ST(Z) + A
2420  NEXT
2500  IF N = 1 THEN 4000

]LIST3000,3999                ARRIVAL MODULE

3000 C1% = C1% + 1
3050  IF P < 3 THEN R =  RND (1):F =  -  LOG (1 - R): GOTO 3130
3100 R =  RND (1):X = 0
3110  IF R > FA(X,1) THEN X = X + 1: GOTO 3110
3120 F = FA(X - 1,2) + (R - FA(X - 1,1)) * (FA(X,2) - FA(X - 1,2)) / (FA(X,1) - FA(X - 1,1))
3130 TA = T + F * AI
3200  FOR Z = 1 TO S%
3210  IF S%(Z) = 0 THEN S = Z:C0% = C0% + 1: GOTO 4250
3220  NEXT
3230 QL% = QL% + 1
3240  IF QM% < QL% THEN QM% = QL%
3250  GOTO 2000

]LIST4000,4249                DEPARTURE MODULE

4000 S%(S) = 0
4010 CS%(S) = CS%(S) + 1
4050 C2% = C2% + 1
4100  IF C2% =  > C% THEN 5000
4150  IF QL% = 0 THEN 2000
4200 QL% = QL% - 1

]LIST4250,4999                SEIZE MODULE

4250 S%(S) = 1
4300  IF P = 2 THEN 4400
4310  IF P = 4 THEN 4400
4320  IF P = 5 THEN 4400
4340 R =  RND (1):F =  -  LOG (1 - R): GOTO 4430
4400 R =  RND (1):X = 0
4410  IF R > FS(X,1) THEN X = X + 1: GOTO 4410
4420 F = FS(X - 1,2) + (R - FS(X - 1,1)) * (FS(X,2) - FS(X - 1,2)) / (FS(X,1) - FS(X - 1,1))
4430 TD(S) = T + F * SI
4600  GOTO 2000

]LIST5000,5199                CALCULATE AVERAGES AND PERCENTAGES

5000  FOR Z = 1 TO S%: IF CS%(Z) = 0 THEN 5030
5010 TS(Z) =  INT (100 * ST(Z) / CS%(Z) + .5) / 100
5020 US(Z) =  INT (10000 * ST(Z) / T + .5) / 100
5030  NEXT
5040 Q0 =  INT (10000 * C0% / C1% + .5) / 100
5050 Q1 =  INT (100 * QT / C1% + .5) / 100
5060  IF C1% = C0% THEN Q2 = 0: GOTO 5080
5070 Q2 =  INT (100 * QT / (C1% - C0%) + .5) / 100
5080 QA =  INT (100 * QT / T + .5) / 100
```

Listing 1 continued on page 164

Listing 1 continued:

```
]LIST5200,5399             SELECT OUTPUT DEVICE

5200  HOME : PRINT  CHR$ (7): PRINT  CHR$ (7): VTAB (7)
5210  PRINT  TAB( 10)"SIMULATION COMPLETED"
5220  PRINT : PRINT  TAB( 13)"READY TO REPORT"
5230  PRINT : PRINT  TAB( 11)"Shall Report go to"
5240  PRINT : PRINT  TAB( 7)"SCREEN (S) or PRINTER (P) ?"
5250  PRINT : PRINT  TAB( 19)" ";: GET A$
5260  IF A$ = "S" THEN 5700
5270  IF A$ = "P" THEN 5400
5280  PRINT  CHR$ (7): PRINT "  Please answer 'S' or 'P'": GOTO 5250

]LIST5400,5699          OUTPUT TO PRINTER

5400  HOME : PRINT : INPUT "What is Date of Report? ";D$
5410  PRINT : PRINT "What is Project Identification?"
5420  PRINT : INPUT I$
5430  PRINT : PRINT "Press RETURN when PRINTER is ready   ";: GET A$
5440  PR# 1
5450  PRINT : PRINT  TAB( 12)D$: PRINT
5460  PRINT  TAB( 40 -  LEN (I$) / 2)I$
5470  PRINT  TAB( 32)"QUEUE SIMULATION"
5480  PRINT : PRINT : PRINT
5490  PRINT  TAB( 12)"1 (ONE) QUEUE SERVED BY ";S%;" PARALLEL SERVICE STATIONS
5500  PRINT  TAB( 12)"AVERAGE ARRIVAL INTERVAL WAS SPECIFIED AS ";AI;" TIME UNITS"
5510  PRINT  TAB( 12)"AVERAGE SERVICE TIME     WAS SPECIFIED AS ";SI;" TIME UNITS"
5520  PRINT  TAB( 12)"QUEUE LENGTH AT START OF SIMULATION WAS ";QL
5530  PRINT : PRINT  TAB( 12)"STATUS OF SERVICE STATIONS AT START WAS:"
5540  PRINT : PRINT  TAB( 20)"STATION"; TAB( 36)"STATUS": PRINT
5550  FOR Z = 1 TO S%: IF A$(Z) = "Y" THEN S$(Z) = "USED"
5560  IF A$(Z) <  > "Y" THEN S$(Z) = "OPEN"
5570  PRINT  TAB( 23)Z; TAB( 37)S$(Z): NEXT
5580  PRINT : PRINT  TAB( 12)"SAMPLE SIZE IS ";C%;" DEPARTURES"
5590  PRINT : PRINT  TAB( 12)"TIME ELAPSED FOR SIMULATION IS "; INT (T + .5);" TIME UNITS"
5600  PRINT : PRINT  TAB( 12)"STATUS OF SERVICE STATIONS AT END IS:": PRINT : PRINT  TAB( 12)"STATION  NUMBER OF  UTIL
     IZATION   AVERAGE TIME  STATUS"
5610  PRINT  TAB( 12)"           DEPARTURES      %         PER SERVICE": PRINT
5615  FOR Z = 1 TO S%: IF S%(Z) = 0 THEN S$(Z) = "OPEN"
5620  IF S%(Z) = 1 THEN S$(Z) = "USED"
5625  PRINT  TAB( 15)Z; TAB( 24)CS%(Z); TAB( 35)US(Z); TAB( 49)TS(Z); TAB( 22)S$(Z): NEXT
5630  PRINT : PRINT : PRINT  TAB( 18)"QUEUE CONTENT"; TAB( 42)"ENTRIES      ZERO"
5640  PRINT  TAB( 12)"CURRENT  MAXIMUM  AVERAGE"; TAB( 40)"TOTAL  ZEROS    %"
5650  PRINT  TAB( 15)QL%; TAB( 24)QM%; TAB( 32)QA; TAB( 41)C1%; TAB( 8)C0%; TAB( 16)Q0
5660  PRINT : PRINT  TAB( 12)"AVERAGE WAIT TIME"; TAB( 42)"AVERAGE WAIT TIME": PRINT  TAB( 15)"ALL ENTRIES"; TAB( 40)"
     UNITS ENTERING QUEUE"
5670  PRINT  TAB( 18)Q1; TAB( 48)Q2
5680  IF P > 1 THEN 6500
5690  PR# 0: GOTO 6000

]LIST5700,5999          OUTPUT TO SCREEN

5700  HOME : PRINT
5710  PRINT "             QUEUE SIMULATION"
5720  PRINT : PRINT  TAB( 2)"MEAN ARRV T"; TAB( 15)AI; TAB( 24)"MEAN SERV T"; TAB( 36)SI
5730  PRINT  TAB( 2)"QUEUE START"; TAB( 15)QL; TAB( 24)"STATIONS"; TAB( 36)S%
5740  PRINT  TAB( 2)"SAMPLE SIZE"; TAB( 15)C%; TAB( 24)"TOT TIME"; TAB( 35) INT (T + .5)
5750  PRINT : PRINT " STAT  DEPART  UTILIZ  AVG TIME  STATUS": PRINT
5760  FOR Z = 1 TO S%
5770  IF S%(Z) = 0 THEN S$(Z) = "OPEN"
5780  IF S%(Z) = 1 THEN S$(Z) = "USED"
5790  PRINT  TAB( 4)Z; TAB( 9)CS%(Z); TAB( 17)US(Z); TAB( 25)TS(Z); TAB( 35)S$(Z)
5800  NEXT
5810  PRINT : PRINT "    QUEUE CONTENT       ENTRIES     %"
5820  PRINT " CURR  MAXI  AVERAGE  TOTAL ZEROS ZERO"
5830  PRINT  TAB( 2)QL%; TAB( 8)QM%; TAB( 14)QA; TAB( 23)C1%; TAB( 29)C0%; TAB( 35)Q0
5840  PRINT  TAB( 2)"AVG WAIT A"; TAB( 13)Q1; TAB( 22)"AVG WAIT Z"; TAB( 33)Q2
5850  PRINT : PRINT "Do you want printed copy? Then press 'Y'"
5860  PRINT "Otherwise press RETURN when ready     ";: GET A$
5870  IF A$ = "Y" THEN 5400

]LIST6000,6499          SELECT MORE SIMULATIONS OR END

6000  HOME : PRINT : PRINT
6010  PRINT "Want to do another Simulation (Y/N) ?"
6020  PRINT : PRINT  TAB( 19)" ";: GET A$
6030  IF A$ = "Y" THEN  CLEAR : DIM FA(25,2),FS(25,2): RESTORE : GOTO 7200
6040  IF A$ = "N" THEN  END
6050  PRINT : PRINT  CHR$ (7): PRINT "Please answer 'Y' or 'N'": GOTO 6020
```

Listing 1 continued on page 166

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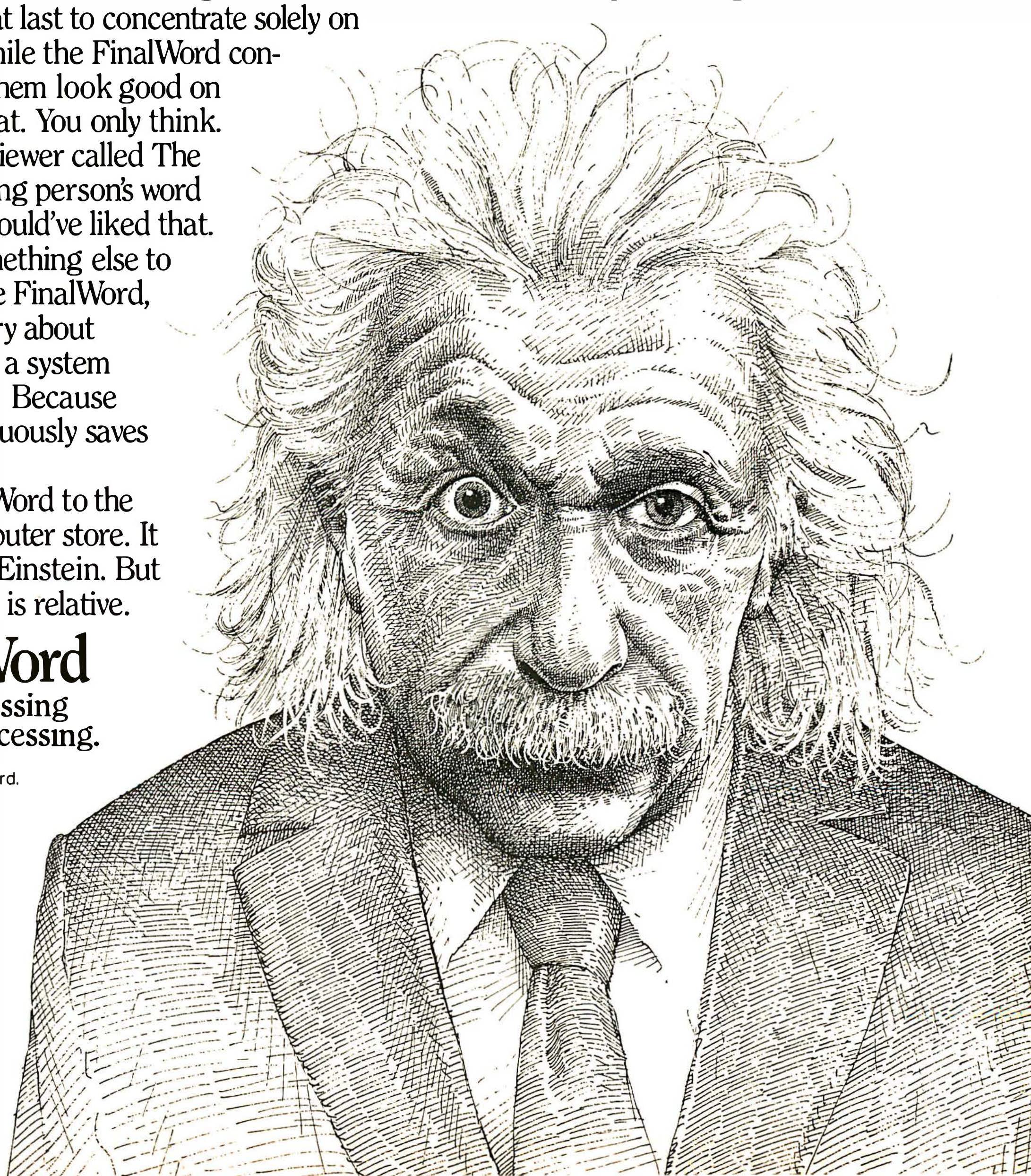
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Listing 1 continued:

```
]LIST6500,6999          AUXILIARY PRINTER OUTPUT

6500  PRINT : PRINT : PRINT  TAB( 12)"NOTE:"
6510  ON P GOTO 5690,6520,6550,6580,6610
6520  PRINT  TAB( 12)"SERVICE TIME HAD PROBABILITY DISTRIBUTION:": PRINT
6530  GOSUB 6750
6540  PRINT : GOTO 5690
6550  PRINT  TAB( 12)"ARRIVAL TIME HAD PROBABILITY DISTRIBUTION:": PRINT
6560  GOSUB 6700
6570  PRINT : GOTO 5690
6580  PRINT  TAB( 12)"ARRIVAL AND SERVICE HAD IDENTICAL NON-POISSON DISTRIBUTION:": PRINT
6590  GOSUB 6700
6600  PRINT : GOTO 5690
6610  PRINT  TAB( 12)"ARRIVAL TIME HAD PROBABILITY DISTRIBUTION:": PRINT
6620  GOSUB 6700
6630  PRINT : PRINT
6640  PRINT  TAB( 12)"SERVICE TIME HAD PROBABILITY DISTRIBUTION:": PRINT
6650  GOSUB 6750
6660  PRINT : GOTO 5690
6700 X = 0
6710  PRINT  TAB( 12)FA(X,1);" ";FA(X,2);" ";
6720  IF FA(X,1) = 1 THEN  RETURN
6730 X = X + 1: GOTO 6710
6750 X = 0
6760  PRINT  TAB( 12)FS(X,1);" ";FS(X,2);" ";
6770  IF FS(X,1) = 1 THEN  RETURN
6780 X = X + 1: GOTO 6760


]LIST7000,7199          OPENING SCREEN

7000  HOME
7010  PRINT : PRINT : PRINT : PRINT
7020  PRINT "    *****************************"
7030  PRINT "    *                           *"
7040  PRINT "    *     QUEUE SIMULATION      *"
7050  PRINT "    *                           *"
7060  PRINT "    *           BY              *"
7070  PRINT "    *                           *"
7080  PRINT "    *     E HART RASMUSSEN      *"
7090  PRINT "    *          P M S            *"
7100  PRINT "    *                           *"
7110  PRINT "    *****************************"
7120  PRINT : PRINT : PRINT
7130  PRINT "       Press RETURN to start"
7140  PRINT : PRINT  TAB( 19): GET A$


]LIST7200,7599          ESTABLISH PROBABILITY DISTRIBUTIONS

7200  HOME
7210  PRINT "  Shall ARRIVAL and SERVICE have"
7220  PRINT : PRINT "  identical Distributions (Y/N)  ";: INPUT A$
7230  IF A$ = "Y" THEN P = 1: GOTO 7260
7240  IF A$ = "N" THEN P = 2: GOTO 7300
7250  PRINT  CHR$ (7): PRINT "  Please answer 'Y' or 'N'  ";: INPUT A$: GOTO 7230
7260  PRINT : PRINT "  Are they both Poisson  ";: INPUT A$
7270  IF A$ = "Y" THEN 7600
7280  IF A$ = "N" THEN P = 4: GOTO 7400
7290  PRINT  CHR$ (7): PRINT "  Please answer 'Y' or 'N'  ";: INPUT A$: GOTO 7270
7300  PRINT : PRINT "  Does ARRIVAL have Poisson  ";: INPUT A$
7310  IF A$ = "Y" THEN 7400
7320  IF A$ = "N" THEN P = 3: GOTO 7360
7330  PRINT  CHR$ (7): PRINT "  Please answer 'Y' or 'N'  ";: INPUT A$: GOTO 7310
7360  PRINT : PRINT "  Does SERVICE have Poisson  ";: INPUT A$
7370  IF A$ = "Y" THEN 7400
7380  IF A$ = "N" THEN P = 5: GOTO 7400
7390  PRINT  CHR$ (7): PRINT "  Please answer 'Y' or 'N' ";: INPUT A$: GOTO 7370
7400  ON P GOTO 7600,7410,7420,7430,7440
7410  GOSUB 7550: GOTO 7600
7420  GOSUB 7500: GOTO 7600
7430  GOSUB 7500: RESTORE : GOSUB 7550: GOTO 7600
7440  GOSUB 7500: GOSUB 7550: GOTO 7600
7500 X =  - 1
7510 X = X + 1: READ FA(X,1),FA(X,2)
7520  IF FA(X,1) < 1 THEN 7510
7530  RETURN
7550 X =  - 1
7560 X = X + 1: READ FS(X,1),FS(X,2)
7570  IF FS(X,1) < 1 THEN 7560
7580  RETURN
```

Listing 1 continued on page 168



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Listing 1 continued:

```
]LIST7600,7999          INPUT SIMULATION DATA

7600  HOME : PRINT
7610  PRINT : INPUT "What is AVERAGE Arrival Interval?  ";AI
7620  PRINT : INPUT "What is AVERAGE Service Time?      ";SI
7630  PRINT : INPUT "How many Service Stations are used? ";S%
7640  PRINT : PRINT "Is there a waiting Queue at Start ";: INPUT A$
7650  IF A$ = "N" THEN  PRINT : GOTO 7680
7660  IF A$ <  > "Y" THEN  PRINT  CHR$ (7): PRINT "Please answer 'Y' or 'N' ";: INPUT A$: GOTO 7650
7670  PRINT : INPUT "How many are waiting?                   ";QL%:QL = QL%:QM% = QL%: PRINT
7680  PRINT "Are any Service Stations in Use   ";: INPUT A$
7690  IF A$ = "N" THEN 7900
7700  IF A$ <  > "Y" THEN  PRINT  CHR$ (7): PRINT "Please answer 'Y' or 'N' ";: INPUT A$: GOTO 7690
7710  IF S% = 1 THEN A$(1) = "Y": GOTO 7900
7720  PRINT : PRINT "    Service Station #   In Use (Y/N)": PRINT
7730  FOR X = 1 TO S%
7740  PRINT "              ";X;: INPUT "                ";A$(X)
7750  NEXT
7900  PRINT : PRINT : INPUT "Size of Simulation Sample:      ";C%


]LIST8000,8799               CALCULATE FIRST ARRIVAL AND DEPARTURE(S) TIMES

8000  HOME : PRINT : PRINT : PRINT : PRINT : PRINT  TAB( 15)"PLEASE WAIT"
8010  PRINT : PRINT  TAB( 10)" ";: FLASH : PRINT "SIMULATION RUNNING"
8020  NORMAL
8090  IF P < 3 THEN R =  RND (1):F =  -  LOG (1 - R): GOTO 8130
8100 R =  RND (1):X = 0
8110  IF R > FA(X,1) THEN X = X + 1: GOTO 8110
8120 F = FA(X - 1,2) + (R - FA(X - 1,1)) * (FA(X,2) - FA(X - 1,2)) / (FA(X,1) - FA(X - 1,1))
8130 TA = F * AI
8150  FOR Z = 1 TO S%
8160  IF A$(Z) = "Y" THEN S%(Z) = 1
8170  IF S%(Z) = 0 THEN TD(Z) = S% * 100 * AI: GOTO 8300
8180  IF P = 4 THEN 8240
8190  IF P = 5 THEN 8240
8200 R =  RND (1):F =  -  LOG (1 - R): GOTO 8270
8240 R =  RND (1):X = 0
8250  IF R > FS(X,1) THEN X = X + 1: GOTO 8250
8260 F = FS(X - 1,2) + (R - FS(X - 1,1)) * (FS(X,2) - FS(X - 1,2)) / (FS(X,1) - FS(X - 1,1))
8270 TD(Z) = F * SI
8300  NEXT
8500  GOTO 2000


]LIST8800,              ERRORS IN DATA STATEMENTS

8800  HOME : PRINT : PRINT :
8810  FOR X = 1 TO 3: PRINT  CHR$ (7): NEXT
8820  PRINT "    PLEASE CORRECT THE DATA STATEMENTS"
8830  PRINT : PRINT : PRINT : PRINT "       NON-POISSON DISTRIBUTIONS"
8840  PRINT : PRINT "       SHOULD BE  IN DATA STATEMENTS"
8850  PRINT : PRINT "          STARTING AT LINE 9000"
8860  PRINT : LIST 9000,
8870  END
```

Text continued from page 160:

```
9000DATA0,.25,.1,.25,.35,.5,.65,1.5,
.9,1.75,1,1.75
9010DATA0,.75,1,1.25
```

assigns a distribution according to curve 3 to arrival intervals but distributes service times according to curve 2. Make sure that the defined distribution averages a value of 1.

Some Sample Problems

Parts a through f of figure 4 show examples of printed output from simulations done by the program. Notice that all input data is repeated on the printed report. Parts e and f of the figure show simulations using non-Poisson distributions. This is noted at the bottom of the report; and the coordinates for the specified distribution curve(s) are shown. Part c of the figure shows a simulation of three parallel service stations. Notice that station 1 has been used most often. This is because of the way the program chooses open stations. The average utilization factor of 91.6 percent for all three stations is close to the theoretical, overall utilization factor of 90.9 percent.

The results of the simulation are summarized in table 4 and compared with the theoretical values (where this is possible), which can be calculated using the formulas listed in table 1. Notice that even with 5000 simulations there is up to 20 percent difference between the analytical and the simulated results. This does not

Variable	Description	Input	Output: Printer	Output: Screen
A	Time advance			
AI	Mean arrival interval	yes	yes	yes
A$	Answer to yes/no question			
A$(Z)	Station status at start	yes	yes	
C%	Sample size	yes	yes	yes
C0%	Number of arrivals with no wait time		yes	yes
C1%	Total number of arrivals		yes	yes
C2%	Total number of departures			
CS%(Z)	Number of departures from Station Z		yes	yes
D$	Date of report	yes	yes	
F	Simulation factor, a function of random			
FA(a,2)	Probability distribution for arrival intervals			
FS(b,2)	Probability distribution for service intervals			
I$	Project identification	yes	yes	
N	Switch for next event (0 = arrival; 1 = departure)			
P	Switch for type of probability distributions			
Q0	Percent of arrivals with no wait time		yes	yes
Q1	Average wait time, all arrivals		yes	yes
Q2	Average wait time, arrivals entering queue		yes	yes
QA	Average length of queue		yes	yes
QL	Length of queue at start	yes	yes	yes
QL%	Length of queue		yes	yes
QM%	Maximum length of queue		yes	yes
QT	Cumulative queue time (i.e., SUM QL%*T)			
R	Random number = RND(1)			
S	Station number with earliest departure			
S%	Number of service stations	yes	yes	yes
S%(Z)	Station status; 0 = open, 1 = used			
S$(Z)	Station status		yes	yes
ST(Z)	Total time Station Z has been in use			
SI	Mean service time, all stations	yes	yes	yes
T	Time, cumulative from start		yes	yes
TA	Time for next arrival			
TD(Z)	Time for departure from Station Z			
TS(Z)	Average service time at Station Z		yes	yes
US(Z)	Percent of utilization of Station Z		yes	yes
X	General counter			
Z	Counter for stations			

Table 2: *Queue simulation variables.*

indicate any flaw in the program but merely illustrates the possible differences between a finite and an infinite population.

A comparison of lines 1, 2, and 3 in table 4 shows that multiple service channels with identical total capacity provide slightly improved service as more channels are used. A comparison of lines 1 and 4 shows the dramatic reduction in queue length and waiting time when a second ser-

Text continued on page 174

Arrival Interval	Service Interval	Value of P
Poisson	Poisson	1
Poisson	Non-Poisson	2
Non-Poisson	Poisson	3
Non-Poisson	Same non-Poisson function as in Arrival Interval column	4
Non-Poisson	Different non-Poisson function than in Arrival Interval column	5

Table 3: *P values.*

Figure 4: *Simulation results with (4a) one service station, (4b) two service stations, (4c) three service stations, (4d) doubled service capacity, (4e) service time has probability function from curve 2 of figure 2, and (4f) both service and arrival times have probability functions from curve 2 of figure 2.*

(4a)

```
1 (ONE) QUEUE SERVED BY 1 PARALLEL SERVICE STATIONS
AVERAGE ARRIVAL INTERVAL WAS SPECIFIED AS 11 TIME UNITS
AVERAGE SERVICE TIME     WAS SPECIFIED AS 10 TIME UNITS
QUEUE LENGTH AT START OF SIMULATION WAS 8

STATUS OF SERVICE STATIONS AT START WAS:

          STATION          STATUS

             1              USED

SAMPLE SIZE IS 5000 DEPARTURES

TIME ELAPSED FOR SIMULATION IS 55470 TIME UNITS

STATUS OF SERVICE STATIONS AT END IS:

STATION   NUMBER OF  UTILIZATION   AVERAGE TIME  STATUS
          DEPARTURES      %        PER SERVICE

   1         5000       91.98          10.2          OPEN


      QUEUE CONTENT            ENTRIES       ZERO
CURRENT  MAXIMUM  AVERAGE   TOTAL  ZEROS      %
   36       46      10.81    5027   370      7.36

AVERAGE WAIT TIME              AVERAGE WAIT TIME
   ALL ENTRIES              UNITS ENTERING QUEUE
     119.25                        128.73
```

(4b)

```
1 (ONE) QUEUE SERVED BY 2 PARALLEL SERVICE STATIONS
AVERAGE ARRIVAL INTERVAL WAS SPECIFIED AS 11 TIME UNITS
AVERAGE SERVICE TIME     WAS SPECIFIED AS 20 TIME UNITS
QUEUE LENGTH AT START OF SIMULATION WAS 8

STATUS OF SERVICE STATIONS AT START WAS:

          STATION          STATUS

             1              USED
             2              USED

SAMPLE SIZE IS 5000 DEPARTURES

TIME ELAPSED FOR SIMULATION IS 55025 TIME UNITS

STATUS OF SERVICE STATIONS AT END IS:

STATION   NUMBER OF  UTILIZATION   AVERAGE TIME  STATUS
          DEPARTURES      %        PER SERVICE

   1         2531       92.05          20.01         OPEN
   2         2469       88.93          19.82         USED


      QUEUE CONTENT            ENTRIES       ZERO
CURRENT  MAXIMUM  AVERAGE   TOTAL  ZEROS      %
   2        38       7.12    4993   718      14.38

AVERAGE WAIT TIME              AVERAGE WAIT TIME
   ALL ENTRIES              UNITS ENTERING QUEUE
     78.42                         91.59
```

Circle 57 on inquiry card.

(4c)

```
1 (ONE) QUEUE SERVED BY 3 PARALLEL SERVICE STATIONS
AVERAGE ARRIVAL INTERVAL WAS SPECIFIED AS 11 TIME UNITS
AVERAGE SERVICE TIME     WAS SPECIFIED AS 30 TIME UNITS
QUEUE LENGTH AT START OF SIMULATION WAS 0

STATUS OF SERVICE STATIONS AT START WAS:

        STATION          STATUS

           1              USED
           2              USED
           3              OPEN

SAMPLE SIZE IS 5000 DEPARTURES

TIME ELAPSED FOR SIMULATION IS 55615 TIME UNITS

STATUS OF SERVICE STATIONS AT END IS:

STATION  NUMBER OF  UTILIZATION   AVERAGE TIME  STATUS
         DEPARTURES      %        PER SERVICE

   1        1709       93.9          30.56        OPEN
   2        1646       91.71         30.99        OPEN
   3        1645       89.11         30.13        OPEN


      QUEUE CONTENT             ENTRIES      ZERO
CURRENT  MAXIMUM  AVERAGE   TOTAL  ZEROS      %
   0        33      6.06     4998   774     15.49

AVERAGE WAIT TIME               AVERAGE WAIT TIME
   ALL ENTRIES                UNITS ENTERING QUEUE
      67.47                           79.83
```

(4d)

```
1 (ONE) QUEUE SERVED BY 2 PARALLEL SERVICE STATIONS
AVERAGE ARRIVAL INTERVAL WAS SPECIFIED AS 11 TIME UNITS
AVERAGE SERVICE TIME     WAS SPECIFIED AS 10 TIME UNITS
QUEUE LENGTH AT START OF SIMULATION WAS 0

STATUS OF SERVICE STATIONS AT START WAS:

        STATION          STATUS

           1              USED
           2              OPEN

SAMPLE SIZE IS 5000 DEPARTURES

TIME ELAPSED FOR SIMULATION IS 55796 TIME UNITS

STATUS OF SERVICE STATIONS AT END IS:

STATION  NUMBER OF  UTILIZATION   AVERAGE TIME  STATUS
         DEPARTURES      %        PER SERVICE

   1        2973       54.6          10.25        USED
   2        2027       36.27          9.98        OPEN


      QUEUE CONTENT             ENTRIES      ZERO
CURRENT  MAXIMUM  AVERAGE   TOTAL  ZEROS      %
   0        9       .24      5000   3556    71.12

AVERAGE WAIT TIME               AVERAGE WAIT TIME
   ALL ENTRIES                UNITS ENTERING QUEUE
      2.72                            9.42
```

(4e)

```
1 (ONE) QUEUE SERVED BY 1 PARALLEL SERVICE STATIONS
AVERAGE ARRIVAL INTERVAL WAS SPECIFIED AS 11 TIME UNITS
AVERAGE SERVICE TIME     WAS SPECIFIED AS 10 TIME UNITS
QUEUE LENGTH AT START OF SIMULATION WAS 5

STATUS OF SERVICE STATIONS AT START WAS:

        STATION         STATUS

           1              USED

SAMPLE SIZE IS 5000 DEPARTURES

TIME ELAPSED FOR SIMULATION IS 55556 TIME UNITS

STATUS OF SERVICE STATIONS AT END IS:

STATION  NUMBER OF  UTILIZATION   AVERAGE TIME  STATUS
         DEPARTURES      %        PER SERVICE

   1        5000       89.66          9.96         OPEN

     QUEUE CONTENT           ENTRIES       ZERO
CURRENT  MAXIMUM  AVERAGE   TOTAL  ZEROS     %
   1        24      3.11     4995   533     10.67

AVERAGE WAIT TIME              AVERAGE WAIT TIME
   ALL ENTRIES               UNITS ENTERING QUEUE
      34.59                         38.72

NOTE:
SERVICE TIME HAD PROBABILITY DISTRIBUTION:

0 .75 1 1.25
```

(4f)

```
1 (ONE) QUEUE SERVED BY 1 PARALLEL SERVICE STATIONS
AVERAGE ARRIVAL INTERVAL WAS SPECIFIED AS 11 TIME UNITS
AVERAGE SERVICE TIME     WAS SPECIFIED AS 10 TIME UNITS
QUEUE LENGTH AT START OF SIMULATION WAS 0

STATUS OF SERVICE STATIONS AT START WAS:

        STATION         STATUS

           1              OPEN

SAMPLE SIZE IS 5000 DEPARTURES

TIME ELAPSED FOR SIMULATION IS 55109 TIME UNITS

STATUS OF SERVICE STATIONS AT END IS:

STATION  NUMBER OF  UTILIZATION   AVERAGE TIME  STATUS
         DEPARTURES      %        PER SERVICE

   1        5000       90.64          9.99         OPEN

     QUEUE CONTENT           ENTRIES       ZERO
CURRENT  MAXIMUM  AVERAGE   TOTAL  ZEROS     %
   1        2        .12     5001   2496    49.91

AVERAGE WAIT TIME              AVERAGE WAIT TIME
   ALL ENTRIES               UNITS ENTERING QUEUE
      1.34                          2.67

NOTE:
ARRIVAL AND SERVICE HAD IDENTICAL NON-POISSON DISTRIBUTION:

0 .75 1 1.25
```

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Text continued from page 169:

Number of Stations	Mean Interval		Percent of Utilization		Average Queue Length		Average Waiting Time	
	Arrival	Service	Analytical	Simulated	Analytical	Simulated	Analytical	Simulated
1	11	10	90.9	92.0	9.1	10.8	100.0	119.3
2	11	20	90.9	90.5	8.7	7.1	95.2	78.4
3	11	30	90.9	91.6	8.3	6.1	91.6	67.5
2	11	10	45.5	47.2	.24	.24	2.6	2.7
1	11	10[1]	90.9	89.7	n.a.	3.1	n.a.	34.6
1	11[2]	10[2]	90.9	90.6	n.a.	.12	n.a.	1.3

Table 4: *Analytical and simulated solutions of queuing problems. The superscript 1 indicates that the service interval had linear probability distribution. The superscript 2 indicates that both the arrival and the service interval had linear probability distribution.*

vice line is opened. (I hope the manager of my local supermarket reads this.)

The significance of the probability distribution is clearly demonstrated by comparing lines 1, 5, and 6. The average waiting time is reduced by 60 percent or more when the service interval follows a narrow, linear distribution rather than the Poisson distribution, and waiting is all but eliminated when both arrival and service intervals fall in a narrow range. This shows that good scheduling reduces wasteful waiting time without having to change the service capacity.

Conclusion

The program I have presented cannot compete with the very powerful, special-purpose simulation languages that are commercially available. But it does give you the ability to analyze queuing situations with your own probability distributions. My program only simulates single-phase service. But with the program's modular structure, you should be able to expand it to include other queuing models. A second Departure module with a second Seize module can be added for simulation of multiphased service. Or a switch can be inserted in the Arrival module to activate an additional service station whenever the queue length exceeds a specified value.

Other possible variations include putting a limitation on the queue length (limited parking space, for example) and counting the number of customers lost because they leave without joining the queue. You could use this information to justify more parking space. In short, the program is flexible; you should be able to adapt it to many queuing situations. ■

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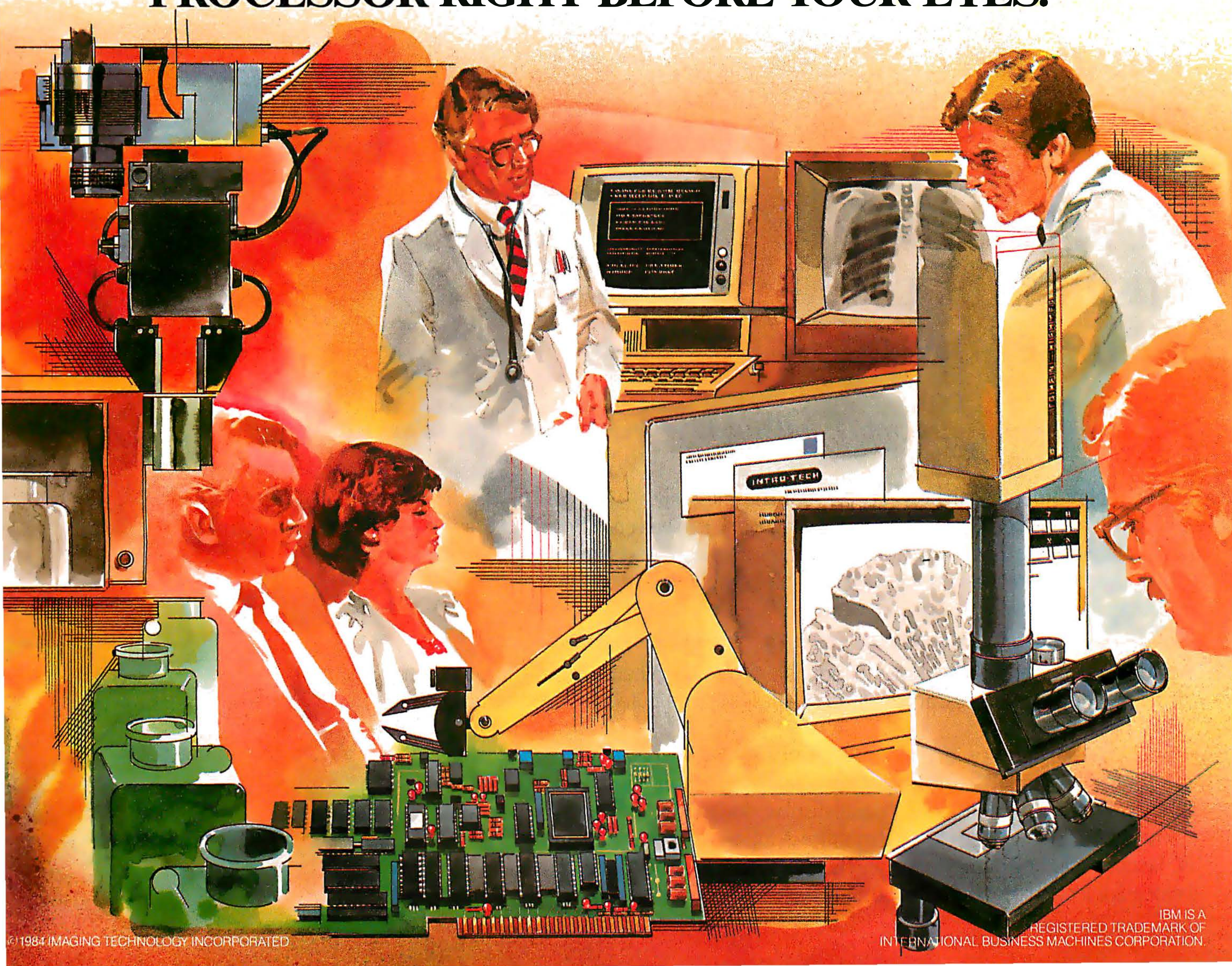
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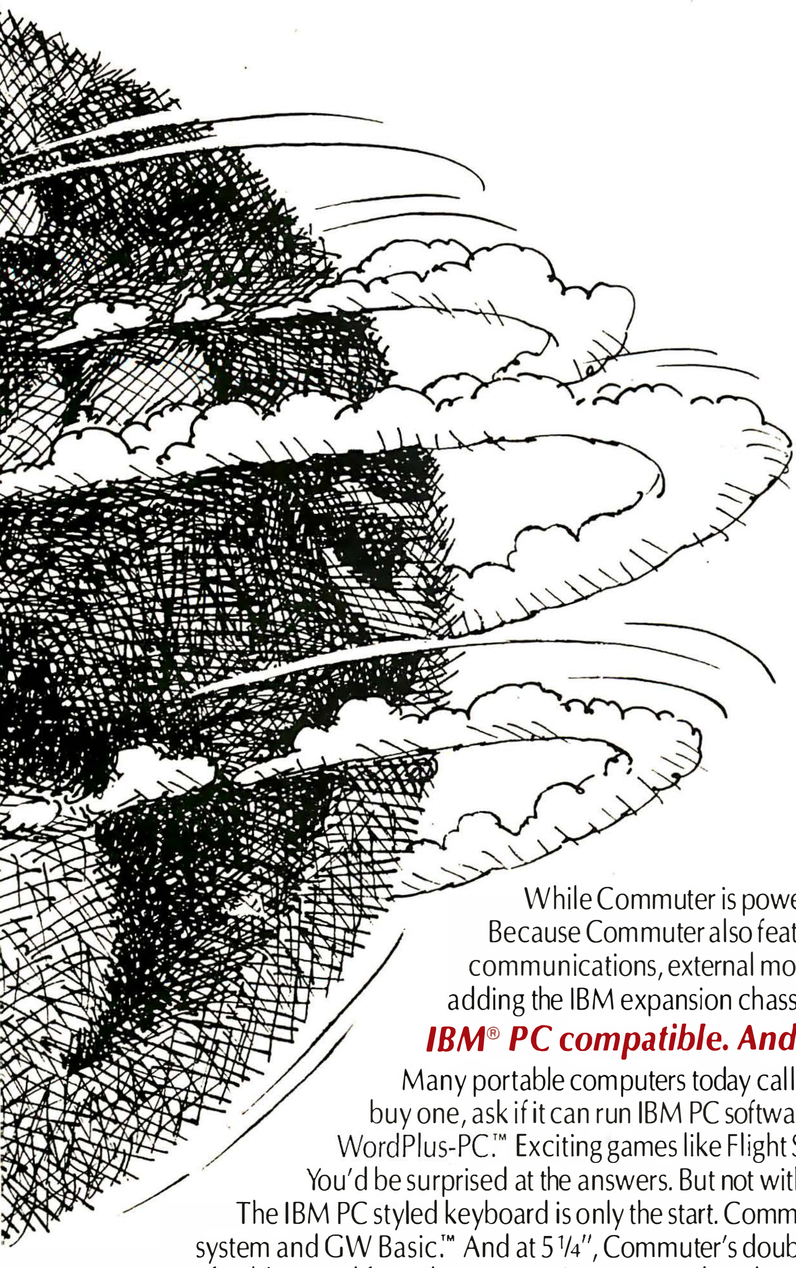
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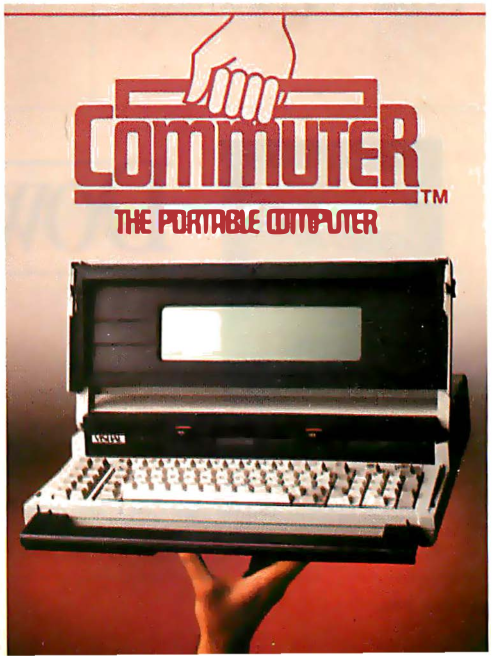
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A Risky Business—An Introduction to Monte Carlo Venture Analysis

A simple method for analyzing business risks

by Pat Macaluso

A business enterprise is aptly named a venture. It is a ship launched on a sea of uncertainty. The business of business is the taking of intelligent risks. Precious resources are committed to what can only be a hope of future gain. To reduce the risk, it would be helpful and profitable to have some insight as to possible future events.

It turns out that future prospects, elusive as they are, can be estimated in a way that is surprisingly useful for business purposes. The method involves four steps: (1) formulate a model of the venture; (2) distribute appropriate data in the model; (3) sample from the model data; (4) analyze the sample.

The Monte Carlo Method

Aside from an investor's knowledge of a proposed venture, the Monte Carlo method requires nothing more than a personal computer and a program that is almost trivial in its simplicity. I'll use an example to illustrate how it works. We take at random a possible selling price, a possible sales volume, and so on. The selections are made from a range of possible values in each case according to the estimated probability of their occurrence. From this sample data, a corresponding outcome is calculated. This process is repeated for the entire range of possibilities. The resulting collection of outcomes is then arranged in sorted order. Examination of this distributed result yields information on the range of future outcomes and the relative chance of their occurrence. We'll see how this is done in detail later on, but the analysis might run something like this: in this business venture there is a 10 percent chance you will lose your shirt; a 65 percent chance you will achieve a 15 percent return on investment after taxes; a 5 percent chance you will really clean up, and so forth.

Such a formulation, even if stated less colorfully or dressed up in graphs and tables, may sound strange or even unsettling. Wouldn't it be simpler and more understandable to take the most likely selling price, sales volume, etc., and come up with a most likely result? Unfortunately that is not the case. Such an approach tends to underestimate the risks. It also throws away most of the information we have that bears on future possibilities.

In projecting sales figures for a product, sales managers can say that a realistic sales level will be 50,000 units. They can also say that there's little chance of 80,000 and no chance of more than 90,000 units being sold. Further, they might add that it is very likely that at least 15,000 units and quite certain that 5000 units will be sold. The manager is expressing a wealth of hard information along with his uncertainty. He is weighing the size of the total market, the effect of competition, replacement rates, captive markets, limits on plant capacity, and so on. In other words, estimates by an informed person, though couched in uncertainty, contain valuable information that bears on future outcomes.

Faced with an investment decision, would you throw such information away, especially if it is easily expressed in a form suited to quantitative analysis? The most likely value or single-point methods do just that. They are quite inferior to the Monte Carlo sampling approach that allows us to use the extra information.

The most likely value method of risk analysis has tended to persist since calculations could be made by

hand and managers felt they understood the result. It certainly seemed more definite and less threatening than a distribution that told of possible bad outcomes as well as the desired profitable ones. Times have changed. Many executives, aided by easier access to computers, have responded with increased sophistication as the safety of investments has become harder to gauge.

We can better understand the nature of the Monte Carlo method with the aid of a simple example. Suppose we wanted to determine the chance of getting "snake eyes," or two ones, in the roll of dice. We can calculate this precisely from probability theory as being one out of 36 tosses on the average. But what if we had no theoretical solution, as is the case with business ventures? There is another way to estimate the chance of snake eyes. We can tally the result of thousands of rolls of the dice. Even better, we can simulate it on a computer. The result will, in general, not be exactly 1 in 36 but it will tend to approach it more and more closely as the size of the sample increases. We will have performed a random-sampling experiment. It is easy, it works, and it is more than adequate when applied to business situations.

How Do I Get Started?

We present here three useful items for anyone who wishes to explore this method of risk analysis: (1) a simple technique for building a model of the venture; (2) a way to construct a sample from a distribution that is universal in its application; (3) a complete but elementary venture-analysis program to carry out the calculations. The program (see listing 1) can serve as a core upon which a more sophisticated or customized system can be built. More details are supplied in the author's book (see text box at the end of this article) but all the essentials are provided in this article.

A word of caution is in order. Compared to the sometimes mind-boggling complexity of actual business ventures, the model shown here will appear quite simplistic. Perhaps crude would be a better description.

Listing 1: *Monte Carlo Venture Analysis program, written in Microsoft BASIC, can be modified for your own use by programming your own model equation and changing the numbers in the DATA statements accordingly.*

```
1000 'MONTE CARLO VENTURE ANALYSIS
1005 '
1010 CLEAR
1020 GOSUB 11000      'Specify runs, samples, etc.
1030 '
1040 FOR L=1 TO NR    'Carry out NR runs (10 max.)
1045 PRINT L
1050 FOR J=1 TO NS    'of NS samples each (200 max.)
1060 '
1070 FOR K=1 TO NV    'for a model with NV variables
1080 P=RND            'Generate a random probability
1090 GOSUB 21000      'Find its posn. in a distrbn. of values
1100 GOSUB 22000      'Find correspg. posn. of variable value
1110 GOSUB 23000      'Calc a sample value V for a variable
1120 NEXT K
1130 '
1140 GOSUB 31000      'Calc a sample outcome from the model
1150 NEXT J
1160 '
1170 GOSUB 41000      'Sort outcomes in ascending order
1180 GOSUB 42000      'Calc statistics for each run
1190 GOSUB 43000      'Calc 11 cum distrbn points for each run
1200 NEXT L
1210 '
1220 GOSUB 44000      'Avg & std devn over all samples
1230 GOSUB 45000      'Std devn of avg of NR run averages
1240 GOSUB 46000      'Cum distn of outcomes over all samples
1250 '
1260 GOSUB 51000      'Display statistics for each run
1270 GOSUB 52000      'Display distn of outcomes over all samples
1280 '
1290 END
1300 '
11000 '--- Initiate the simulation
11010 '
11020 NV=4
11030 DIM OU(200),CD(10,10),ST(10,2),FD(10)
11035 PRINT"PATIENCE PLEASE. RUN NUMBER WILL DISPLAY WHILE COMPUTING."
11040 INPUT"NUMBER OF RUNS";NR
11050 INPUT"SAMPLES PER RUN";NS
11060 INPUT"ENTER RANDOM SEED <-32768 TO 32767>";RS
11070 RANDOMIZE RS
11080 IF NR<2 THEN NR=2:IF NR>10 THEN NR=10
11090 IF NS<10 THEN NS=10:IF NS>200 THEN NS=200
11100 RETURN
11110 '
12000 '--- Sum of squared deviations
12010 '
12020 SS#=0:FOR I=1 TO T
12030 SS#=SS#+(OU(I)-AV)^2:NEXT I:RETURN
12040 '
13000 '--- Standard deviation
13010 '
13020 SD=(SS#/(T-1))^.5:RETURN
13030 '
21000 '--- Find the interval of P
21010 '
21020 FOR I=1 TO 5:READ P2
21030 IF P>P2 AND P<=P1 THEN II=I:PA=P1:PB=P2
21040 P1=P2:NEXT I:READ X$:RETURN
21050 '
22000 '--- Find the corresponding value interval
22010 '
22020 FOR I=1 TO 5:READ V2
22030 IF I=II THEN VA=V1:VB=V2
22040 V1=V2:NEXT I:READ X$:RETURN
22050 '
23000 '--- Calc. a sample value V; assign to model variable
23010 '
23020 V=((PA-P)/(PA-PB))*(VB-VA)+VA
23030 IF K=1 THEN SP=V
23040 IF K=2 THEN UC=V
23050 IF K=3 THEN SV=V
23060 IF K=4 THEN FC=V
23070 RETURN
23080 '
31000 '--- Calc. a sample outcome and running sum for model
31010 '
31020 SO=((SP-UC)*SV)-FC
31030 OU(J)=SO:S#=S#+SO
31040 RESTORE:RETURN
31050 '
41000 '--- Sort sample outcomes in ascending order
41010 '
```

Listing 1 continued on page 181

What good then is such an approach, aside from tutorial use? The answer may be somewhat surprising unless you are already well into this subject. Simple models work remarkably well to the extent that they embody the essentials of the enterprise they represent. There are advantages to stripping away nonessentials. At the very least, the act of analysis sharpens our understanding of the venture. It reveals what weaknesses may exist in the data, which factors are most critical, and so on.

The outcome of a simulation is a way to integrate the complexity of distributed values in a model. It is a tool that helps the entrepreneur make the actual decision. That decision will weigh factors that the model did not or could not include. The user must also decide exactly what the problem is and frame the model accordingly. For example, is a product to be made in new, expanded, or shared facilities? If the latter, how will the effect of displaced products and production turnaround be handled in the model? Is the venture analyzed on its own merits or in comparison with other projects? It is clear that the real work is done both before and after the simulation. The program is just a convenient calculation tool.

Building a Model

The example we will use here is an estimate of the gain (or loss) to be expected in the production and sale of an item with a small-to-modest market. The model we will use is a simple one. Our purpose is to illustrate the technique without getting lost in the details. This will make it easier to highlight the possible weaknesses, as well as the strengths, of this approach.

As a starter, we need a model in the form of an equation that represents the venture. How do we develop such an equation? We can start at the top by noting that our objective, expected gain, can be taken as the difference between total income and total expense before taxes. Thus: Gain = Income − Expense. We proceed with our top-down design by detailing income as: Income = Selling Price × Sales Volume, or SP*SV

Listing 1 continued:

```
41020 D=NS
41030 IF D<=1 THEN RETURN
41040 D=INT(D/2):R=NS-D:EX=0
41050 FOR I=1 TO R:DI=D+I
41060 IF OU(I)<=OU(DI) THEN GOTO 41080
41070 OT=OU(I):OU(I)=OU(DI):OU(DI)=OT:EX=1
41080 NEXT I
41090 IF EX=0 THEN GOTO 41030
41100 EX=0:GOTO 41050
41110 '
42000 '--- Avg, sum of sq devns, std devn for each run
42010 '
42020 T=NS:AV=S#/T:ST(L,0)=AV
42030 GOSUB 12000:ST(L,1)=SS#
42040 GOSUB 13000:ST(L,2)=SD
42050 S#=0:RETURN
42060 '
43000 '--- Extract and store cum. distn in steps of 10%
43010 '
43020 PF=INT(NS/10+.5)
43030 FOR I=0 TO 10:CD(L,I)=OU(I*PF)
43040 NEXT I:CD(L,0)=OU(1)
43050 RETURN
43060 '
44000 '--- Avg and std devn over all samples and runs
44010 '
44020 S#=0:SS#=0:FOR I=1 TO NR
44030 S#=S#+ST(I,0):SS#=SS#+ST(I,1):NEXT I
44040 AV=S#/NR:AD=(SS#/(NS*NR-1))^.5
44050 RETURN
44060 '
45000 '--- Std devn of avg outcomes for NR runs
45010 '
45020 SS#=0:FOR I=1 TO NR
45030 SS#=SS#+(ST(I,0)-AV)^2:NEXT I
45040 SD=(SS#/(NR-1))^.5
45050 RETURN
45060 '
46000 '--- Final distribution in steps of 10%
46010 '
46020 FOR I=0 TO 10:S#=0
46030 FOR M=1 TO NR
46040 S#=S#+CD(M,I):NEXT M
46050 FD(I)=S#/NR:NEXT I
46060 RETURN
46070 '
51000 '--- Display statistics for NR runs
51010 '
51015 PRINT CHR$(26)
51020 PRINT"STATISTICS FOR";NR;"RUNS OF";NS;"SAMPLES EACH. SEED=";RS
51030 PRINT""
51040 PRINT"RUN         AVG OUTCOME      STD DEVN"
51050 PRINT"---         -----------      --------"
51060 PRINT""
51070 FOR I=1 TO NR
51080 PRINT I,ST(I,0),ST(I,2):NEXT I
51090 PRINT""
51100 PRINT"AVG=";AV,"STD DEVN=";SD
51110 PRINT""
51120 INPUT"PRESS RETURN TO CONTINUE";X$
51130 RETURN
51140 '
52000 '--- Display outcomes over all samples and runs
52010 '
52015 PRINT CHR$(26)
52020 PRINT"OUTCOMES FOR";NR*NS;"SAMPLES.  SEED=";RS
52030 PRINT""
52040 PRINT"% CHANCE    OUTCOME WILL EXCEED"
52050 PRINT"--------    -------------------"
52060 PRINT""
52070 FOR I=0 TO 10
52080 PRINT 100-I*10,FD(I):NEXT I
52090 PRINT""
52100 PRINT"AVG=";AV,"STD DEVN=";AD
52110 PRINT""
52120 RETURN
52130 '
62000 '--- Data statements in order as per subr. 23000
62010 '    One pair (5 proby, 5 values) for each model var.
62020 '    Change NV in subr 11000 if model in 31000 changes
62030 '
62040 DATA 1    , .90, .50, .10,0    ,      'SP proby; discount-
62050 DATA 3.00,3.40,4.20,5.00,5.40,       'ed selling price
62060 '
62070 DATA 1    , .85, .50, .15,0    ,      'UC proby.
62080 DATA 0.40,0.45,0.50,0.70,0.90,       'Unit distrn cost
62090 '
62100 DATA 1    , .85, .50 , .20 , 0    ,   'SV proby.
62110 DATA 4000,8000,12000,15000,15000,    'Sales volume
```

Listing 1 continued on page 182

Listing 1 continued:

```
62120 '
62130 DATA  1    , .80 , .50 , .20 , 0    ,'FC proby.
62140 DATA 14000,14000,14000,14000,14000,'Fixed cost
62150 '
62200 'FOR A DIFFERENT VENTURE, PROCEED AS FOLLOWS:
62210 'REPLACE LINE 31020 WITH NEW MODEL EQUATION.
62220 'MODIFY LINES STARTING AT 23030 ACCORDINGLY.
62230 'MODIFY NV IN LINE 11020 IF NECESSARY.
62240 'EDIT DATA SECTION AT 62000 FOR NEW ESTIMATES.
62250 END
```

using BASIC notation. Likewise we can assume that: Expense = Fixed Cost + Variable Cost, or FC+VC. The latter can be expressed as: Variable Cost = Unit Cost × Sales Volume, or VC=UC*SV. Putting it all together, we have:

G = SP*SV − UC*SV − FC

Thus, the formidable phrase "formulate a model of the venture" requires nothing more than a simple equation. Some arbitrary decisions will have to be made on just what

stance, variable costs versus fixed costs in a way that reflects the quantity produced rather than the quantity sold. Likewise, it may be necessary to use a fraction of the anticipated selling prices to allow for discounts. Every venture has its own scenario. The user needs to adjust either the model or the data to allow for the specific case. This can be done in stages by continuing the top-down expansion of the model.

Constructing a Distribution

Each value that may be assigned to a variable, for example, the sales volume, has a probability of occurrence associated with it. We have seen an example of this in the game of dice where a die has possible values of one through six, each with an equal chance of occurrence. The collection of values and their associated probabilities for a given variable is called a distribution. In this case, many tosses of a single die produce a uniform distribution, since each value has the same chance of occurring.

A more common type of distribution is represented by the heights of people. We usually find many people in the five- to six-foot range, somewhat fewer in the four- to five- or the six- to seven-foot range, and many fewer at other heights. If we tabulate and plot the count of the heights, we get something like a bell-shaped curve. This is called a normal or Gaussian distribution. There are a rather large number of different kinds of formal distributions, each with a different shape. Some of them represent actual collections of specific things quite well. The problem with formal distributions is that they require various constants to be determined and specified. It would also be necessary to select a suitable distribution and perform special calculations or transformations to use them.

We present here a simple distribution that avoids all of these complications. It will approximately fit your data, whatever it may be. To illustrate its construction and use, we will con-



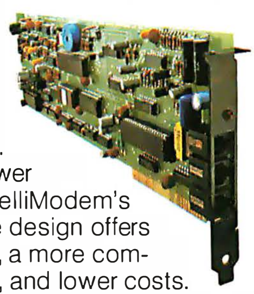
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Number sold	Probability	Meaning
4000	1.00	Certain to sell 4000 or more
8000	0.85	85 percent chance of 8000 or more sales
12,000	0.50	Even chance of 12,000 or more sales
15,000	0.20	20 percent chance of selling all units
15,000	0.00	No chance of sales exceeding units produced

Several points of interest should be noted. First, we start and end with two certainties, namely 100 percent and 0 percent situations. This is not at all difficult for someone who knows the business area being simulated. In our example, the user knows from experience that the established outlets will absorb at least 4000 units. The other limit of 15,000 units is also quite certain. In this example, the user has decided to accept a 20 percent risk of loss of sales in excess of 15,000 units, perhaps counting on a second production run if all goes well. This illustrates an immediate advantage of this method of representing distributions. It naturally and easily takes care of cutoffs at both extremes, including special situations such as captive outlets and lost opportunity.

Another important feature is that the distribution is in cumulated form. This is a great advantage since other distributions must be converted to cumulative distributions before they can be used practically. A cumulative distribution in effect adds up all the chances on one side of any particular value. Instead of saying there is one chance in six of getting a four on the toss of a single die, we say there is a 50 percent chance of getting a four or higher. We can see why we need cumulative estimates in the case of a "continuous" distribution such as the number of units sold. It would be difficult to deal with the 1 out of 10,000 chance that we will sell exactly 8000 units. Much the same applies to the 35 percent chance that between 8000 and 12,000 units will be sold. It's much easier to deal with the 85 percent chance that sales will be greater than 8000. This will become evident when we see how the actual calculations are carried out.

A close look at the estimated sales and their probabilities shows that they are not symmetrically distributed around the 50 percent (or even) chance point. This is often a problem with formal distribution functions since there are many varieties of skewed or nonsymmetric distributions. Again we have an advantage in that our estimate of the probable distribution is directly applied. Another feature is that the 50 percent estimate need not be one of the five cumulative points. The three middle estimates can be any that are suited to the data. It is not uncommon for the second and fourth estimates to be something like 95 percent and 5 percent or 90 and 10, etc. These correspond to easily visualized chances such as one out of twenty, one in ten, and so on. These might correspond to a pessimistic and optimistic estimate in addition to a more central or fifty-fifty estimate.

Sampling from the Distribution

We now have a distribution, that is, a quantitative expression of the uncertainties affecting a variable in our model of the business venture. The question is: how do we use it? In our example, the Monte Carlo method requires us to select at random one of the possible sales levels between 4000 and 15,000. The random selection must conform to the distribution, which is not uniform and for which we have only five points. The simplest method is to assume that the distribution between two successive levels or points is uniform. This allows us to obtain intermediate values by simple or linear interpolation. A plot of our sales volume distribution in figure 1 illustrates the process. If we compare the tabulated distribution with the plot in figure 1 and with the formula

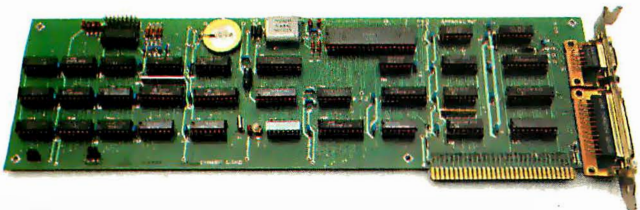
V = (((P1 − P)/(P1 − P2))*(V2 − V1)) + V1

we should be able to see how this works. Thus, using the BASIC ran-

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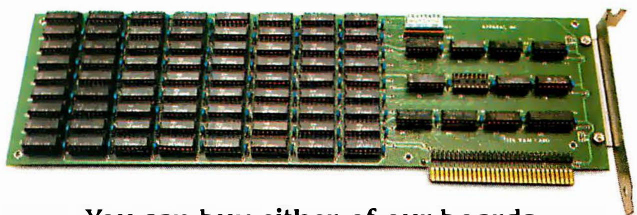


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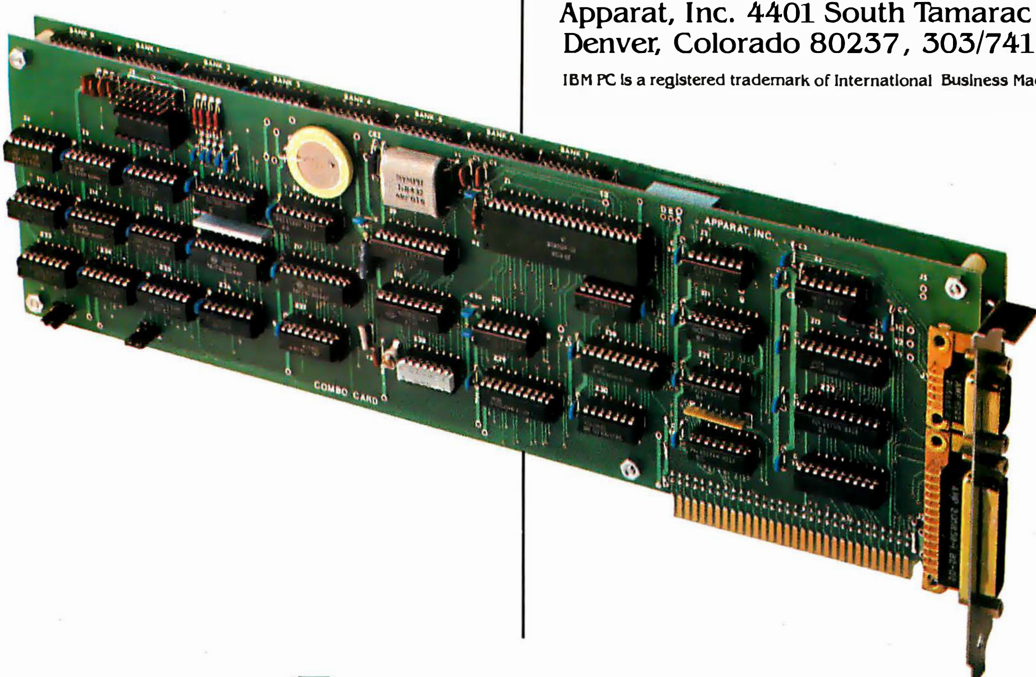
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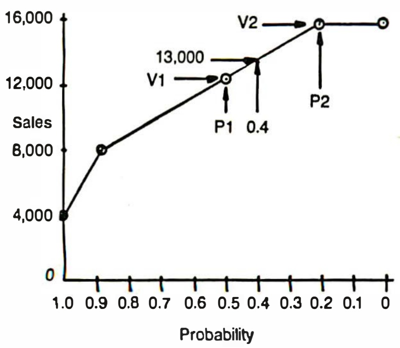


Figure 1: *Sampling by interpolation. The probability of achieving a certain sales figure ranges from 1 (a certainty) to 0 (impossible). The approximate mid-range of 13,000 sales has a probability of 0.4.*

dom-number generator, a random probability P between P1 and P2 selects a sales volume V between V1 and V2.

There are several ways you could arrange such tables relating possible values to their probability of occurrence. The important thing is to be consistent so that your tables, formulas, program, interpretation, and logic all hang together. In the sample venture analysis we are developing here, we will use the format of our sales volume example. The specifications for a variable are: (1) use five levels with probabilities of 1 and 0 at the extremes; (2) estimate values in terms of "equal to or greater than"; (3) always start with the estimate for which the probability equals 1. That's almost all there is to it.

We need to develop similar tables for each of the variables in the equation representing the venture. These are shown as DATA statements at the end of listing 1. The program is now ready to sample them using a succession of random numbers. Each sampled value gets plugged into the equation. This yields one possible outcome. The program does this repeatedly, saving the results in a table of outcomes for further analysis.

Note how the fixed cost, which is a constant, is represented in the DATA statement on line 62140 of the program. This wastes random numbers and running time but it simplifies programming and is very flexible. With this arrangement any variable can be treated as either a constant or a distribution without reprogramming.

Does It Really Work?

At this point you may be wondering whether we can really get away with fitting or representing the smooth curve of a distribution of expected values with straight line segments, and only four of them at that. It turns out that, in almost all cases, the use of precise distributions, or of more points, makes little significant difference in the results. This has also been my own experience with venture analysis in the chemical industry over many years.

If we think about it we can see why this is so. The most obvious consideration is that any estimate of future events is subject to error, however informed it may be. As Murphy, who by the workings of his own law must be counted an optimist, would put it, "The future is uncertain; you can count on it." There is a deeper reason, however, why this simplified approach works. It lies in the use of a distribution or spread of values. The mere fact that an informed estimator has set approximate upper and lower limits adds far more information to the simulation than any refinements in the detailed form of the distribution.

It is the introduction of distributions that transforms the formerly popular (but wrong) single-point estimates into a sound and informative analysis. This does not mean that the forecast of outcomes is necessarily correct. Even when wrong, the method provides good information on which of the variables are most important. It may show that a doubling of promotional expenses will have very little effect, whereas a 10 percent increase in inventories can turn a profit into a loss. Such a use of venture analysis is called sensitivity analysis.

A Venture-Analysis Program

Now we know how to sample a distribution by going in with a random probability P and coming out with a corresponding value V. The program shown in listing 1 implements this and does a complete risk analysis. It embodies our specific model example. The program is easily modified for other venture analyses by simply replacing the equation, or model, in subroutine 31000. It is a no-frills program designed for ease of understanding.

The style of programming followed here consists of putting everything possible into subroutines. These are invoked by a short calling section at the start of the program.

It looks simple and that's the way it should be. We are looking at the main features of the program, avoiding all detail at this level. We see that the program starts with a specification section and ends with a sorted tabulation and display. The simulation is performed in three nested FOR...NEXT loops. The task carried out by each called subroutine is described in the remarks to the right.

Subroutines are used even if they are called only once. There are many advantages to this. Each subroutine performs a single task, which is described in its header. This makes it easy to follow the flow of the program. Another feature is that GOTOs, whether explicit or implied, never branch out of a subroutine. If such an excursion is necessary, a call is made to another subroutine. This is not a dodge since a subroutine always returns to the point immediately following its invocation. We could say that this programming style produces a bunch of grapes (GOSUBs) instead of a bowl of spaghetti (GOTOs). It is much easier to pick your way through a cluster of grapes than a tangle of spaghetti. GOTOs are used, of course, but they branch to points within their own routines. This makes it much safer to modify the program when necessary. It's about the closest approach we can make to structured programming in Microsoft BASIC.

As a further aid to understanding the program, the meaning of the program variables is shown in table 1. The Monte Carlo sampling is carried out in subroutines 21000 through 23000 and is applied to the model equation in subroutine 31000. The outcomes are stored in the array variable OU. They are converted to a

AD	Standard deviation over all samples.
AV	Average or mean.
CD	Array of cumulative distribution values.
FC	Fixed costs.
FD	Array of averages for selected cumulative distribution points.
NR	Number of runs.
NS	Number of samples per run.
NV	Number of variables in model equation.
OU	Array of outcomes for a single run.
P	Probability.
P1	Probability estimate point in a distribution.
P2	Probability estimate point in a distribution.
PA	Store of selected P1.
PB	Store of selected P2.
PF	Step increment for summary cumulative distribution.
RS	Random seed.
S#	Sum.
SD	Standard deviation.
SO	Single outcome calculated from the model equation.
SP	Selling price (effective).
SS#	Sum of squared deviations from the average.
ST	Array of run statistics.
SV	Sales volume.
UC	Unit distribution cost.
V	Sample value calculated from a distribution.
V1	Estimated value point in a distribution.
V2	Estimated value point in a distribution.
VA	Store of selected V1.
VB	Store of selected V2.
X$	Sink for dummy read, input, etc.

Table 1: *Variables used in the Monte Carlo Venture Analysis program.*

cumulative distribution by a Shellsort in subroutine 41000.

All that remains after this is to display the results. We could simply list our 200 outcomes in a table with their associated probabilities. Thus, the 20th outcome in the list would represent the minimum result of 90 percent of the trials. Such a table would not be very appealing. A better solution is to show probable outcomes in steps of 10 percent.

Some Results

With our program complete, our model specified, and our estimates in hand, we can now launch our venture thousands of times and see what the future promises. A typical run of 2000 samples gives the following pro-

jection. All values are rounded to the nearest $100.

Percent Chance	of Gain Exceeding
100	– 1900
90	8900
80	15,300
70	19,900
60	24,300
50	27,900
40	31,100
30	35,000
20	39,400
10	45,600
0	58,400

Not surprisingly, Monte Carlo simulation with its distributed inputs gives a corresponding spread of outcomes. The first thing we note is that there is a possibility of a small loss. If we were to plot the above results we would find the chance of a loss is about 2 percent. The traditional single-point method would ignore the possibility of loss and come up with an overestimation of the gain as a most likely $30,400. This is very reassuring to people who like to keep their head in the sand.

We have achieved our objective of placing a probability estimate on a range of possible outcomes. Remember that we are dealing with essentially a one-shot proposition, and therefore the information in the two extremes is meaningful. If we were really dealing with the long run, then the extremes would hardly matter. We could be virtually certain of achieving something close to the long-term expectation or average of $27,600.

In spite of all that has been and can be said, many users still feel uncomfortable with this form of analysis. The reason is a basic one. This is the human predilection for twisting the facts of uncertainty into something that seems more certain. The analyst can help here by working up the results into a form the decision maker can relate to more easily. One type of analysis that is guaranteed to spark interest is a sensitivity analysis. Simply rerun the analysis with the same random seed but with a small percentage increase in sales. Do the same for each variable in turn and show which variable is most important in affecting the outcome. In models with more variables than in our example, such sensitivities are not always obvious.

Another possibility is to do some "what if?" simulations in which different possible estimates are used. The results can then be presented as a statement of conditions or scenarios required to avoid a loss or make a given profit. Presenting the results in the form of charts or curves can also help.

Have We Taken Enough Samples?

You may have wondered why the program carries out ten runs of 200 samples each. Why not one run of 2000 samples? By making several small runs instead of one large run we obtain information on the adequacy of our sample size. Recall that a Monte Carlo simulation is in the nature of an experiment. It does not give a precise answer even when one is possible. By examining the results of several runs we can get a measure of how well we are zeroing in.

Here's how it works for our example: the following averages are for ten runs of 200 samples each. All the figures, including the standard deviations, are supplied by the program. The standard deviation is a statistical measure of the amount of variation or spread in the data represented by an average:

Run	Average	Standard Deviation
1	28,100	14,100
2	28,000	14,000
3	28,700	13,900
4	27,400	13,200
5	26,800	14,000
6	27,600	13,200
7	26,100	12,500
8	29,000	12,700
9	28,100	13,900
10	25,900	13,200

As expected, we find a fair amount of fluctuation. What about our overall average and standard deviation? For the 2000 samples we have:

27,600 Average
13,400 Standard Deviation

We appear to have gained nothing from our ten-part breakdown. But there is more information to be squeezed from this data. Suppose we take the average of the ten averages and, again courtesy of our program, take a standard deviation. This time it is for the average of the averages. We can do this since each average represents the same sample size. As expected, we get the same average but note the new standard deviation:

27,600 Average
1000 Standard Deviation

Statistical theory tells us that the true average has a 68 percent chance of being within one standard deviation or $1000 of our estimated average. If we had made only one run of 2000 samples, we would have little idea of how we were doing. The large standard deviation of $13,400 would have left us with a range of about $14,000 to $41,000 in which to expect the average in 2 out of 3 chances.

Note that we have given no hard criteria or explicit formula for determining an optimum or safe sample size. Experience shows that a venture analyst should have and does have a feel for what is acceptable. For example, if you had made several ten-run simulations with different sample sizes, you might have come up with:

Samples per Run	Overall Average	Overall Standard Deviation	Standard Deviation of Ten Averages
20	28,100	13,700	3300
100	27,800	13,700	1700
200	27,600	13,400	1000

In view of the approximate nature of the estimates, a sample size of 200 appears adequate. Should your model have more variables you might need to increase the sample size beyond 200. Fortunately, even fairly involved business-risk simulations need no more than five or six of their variables to be distributed. The other variables that are treatable as constants can be directly programmed as such into the model. This saves space and conserves the supply of nonrepeating pseudorandom numbers. It allows a realistic but no-frills simulation to be run on a microcomputer.

Conclusion

We have demonstrated with the aid of a simple example the nature of a

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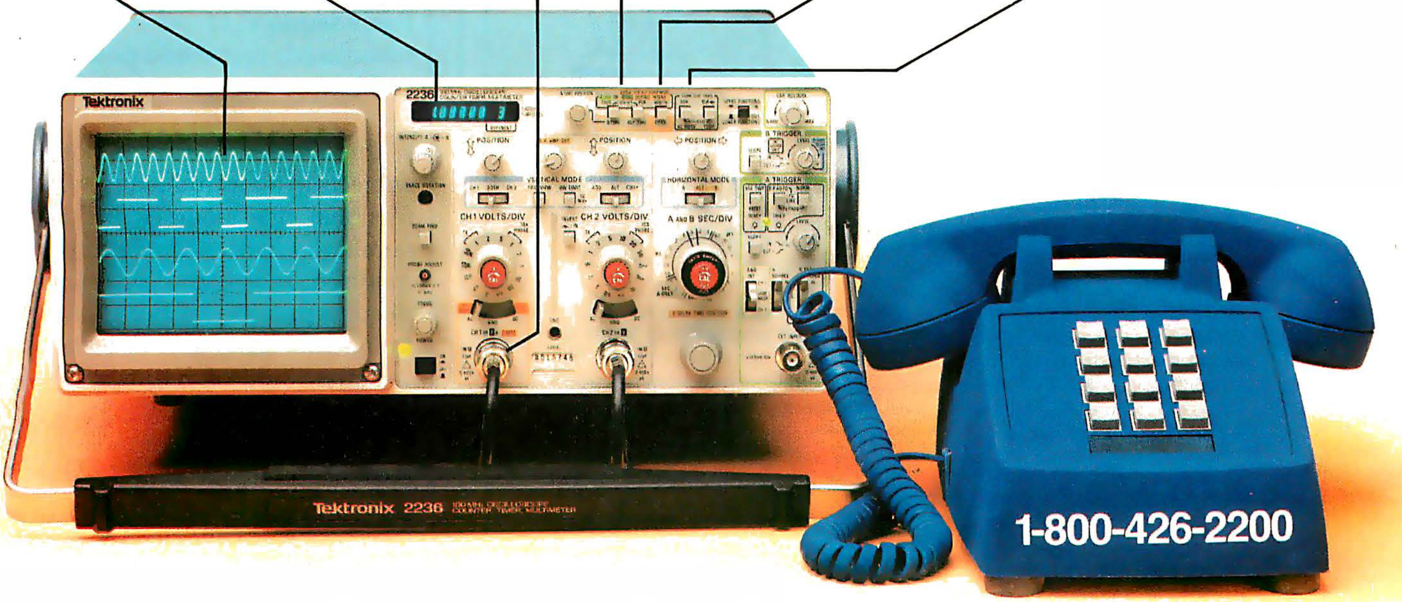
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Monte Carlo simulation and how it can be applied to a business venture. In particular we have seen that:

- An expert's estimates of the uncertainties of his field—sales, production, marketing, costs, timings, and trends—is valuable information. It is the raw material for risk analysis by means of Monte Carlo simulation.
- There is a very simple, practically universal technique for expressing such estimates in the form of a distribution and taking random samples from it.
- A model can be built as each situation requires by a simple top-down design method that starts broadly and gets more detailed in stages.
- We can apply simple statistics through a program to get a handle on the adequacy of our experimental (simulated) probe into possible outcomes.

This article has touched on these subjects in an introductory way. Professional risk analyses will require familiarity with the venture to be modeled. Professional programs may need to provide for things like multiple years, time value of money, and various kinds of return on investment.

A personal computer makes it convenient to include such features incrementally. The simplicity of Monte Carlo sampling allows each programming addition to be small and modular. Fast execution times are not necessary. This allows interpreter languages to be used for easy changes in models and data. The availability of state-of-the-art implementations of BASIC and APL, particularly on the IBM PC, is favorable to increased use of this form of simulation.■

This article includes material from the author's book Learning Simulation Techniques on a Microcomputer Playing Blackjack and other Monte Carlo Games *published by Tab Books.*

Pat Macaluso (9 Church Ct., White Plains, NY 10603) is a consultant, teacher, and writer on microcomputers with special interests in APL and applications software development.

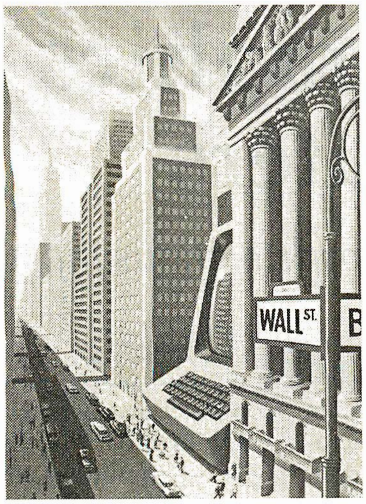
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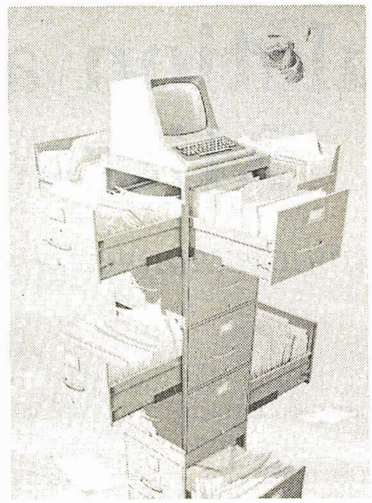
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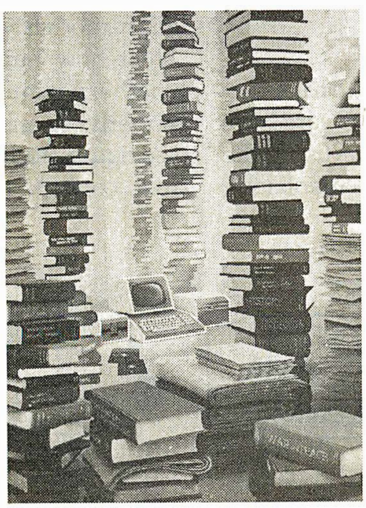
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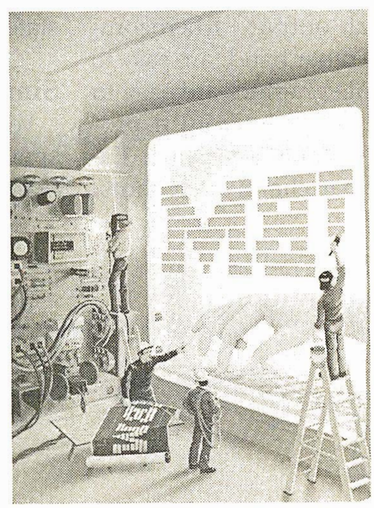
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Simulation and Graphics on Microcomputers

Some graphic examples that may be worth a thousand words

by Ronald R. Miller

It is difficult to relate the output of a simulation model to the physical system it describes. Graphic representations of results can make simulations more credible and more interesting. On most large computers, however, there are software and hardware barriers between the user and graphical output. Microcomputers, on the other hand, are easy to use, and simple graphics are easy to produce without help from a programmer or systems specialist. Examples show bar charts, snapshots, dot plots, bit density plots, and contour plots of simulation results generated using an Atari 800 microcomputer, a color television, and an Epson MX-80 printer (costing about $600) with graphics capability. All the user must do to obtain such plots is write short programs (less than 100 statements) in BASIC.

Simulations Need Graphics

Vendors of graphics software have spent a lot of money advertising the benefits of graphics in displaying computer output. Virtually every computer installation boasts of some graphics capability. Yet those of us who use computers and their output see very little graphics in practice. That is unfortunate because graphics is a tremendous aid in validating, verifying, and making credible simulation models.

Just how hard is it to determine whether a simulation model behaves properly? Consider the usual path (see figure 1) a model follows in going from concept to computer output.

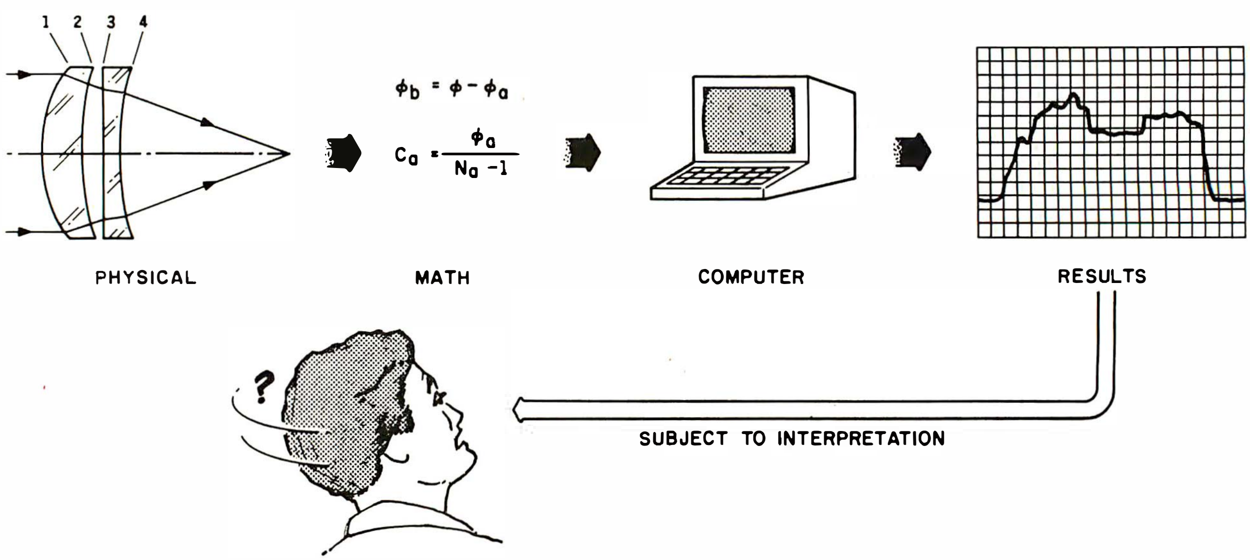


Figure 1: *Distance between the simulation user and the underlying system. It is difficult to relate the result of a simulation to the physical system it describes.*

Step 1 is usually the translation of the concept, say of a physical system, into a mathematical model. There are many pitfalls in this translation. It takes a mathematician of great skill to build a model of a physical system that adequately captures its essential features.

There are even more pitfalls in building computer models from mathematical models. The computer model requires a translation from traditional mathematics into numerical methods and discrete computations. Most simulation specialists are aware of the problems computers have with rounding and truncating numbers. Some are aware of the fact that computer solutions of perfectly good equations can go bad without any warning. Few simulation specialists realize, however, that a computer model of any complexity can never be fully tested. For example, each branching condition in a computer program creates two different execution paths. It is not uncommon for a small simulation program to have over 100 branching conditions. This represents a potential of two to the hundredth power or 1.27 by 10^{30} paths through the program. Even at today's computer speeds, one could never test every path.

Finally, there is the interpretation of model results. Each person usually has a different idea of what the results mean and whether they are valid in a particular situation. This problem is compounded by the fact that the mathematical modeler, the programmer, and the user are often different people, and each typically understands little of the others' areas of expertise. Under these conditions, believing the results of a simulation is like believing a rumor after 100 people have passed it on.

Graphics provides a window through which one can observe the behavior of a simulation. Everyone agrees that this is useful. Yet even with a lot of motivation and money, there is still not much graphics. Why? The answer is simple. Graphics is difficult to generate. The layers of hardware, software, and people between the computer and its users are a barrier that few can afford to penetrate.

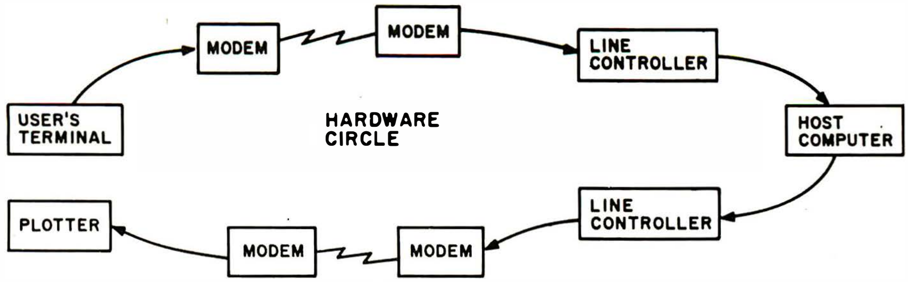


Figure 2: *Layers of hardware between a computer user and a plotter. Many layers of hardware make systems inflexible and unreliable.*



Figure 3: *Layers of software between the user and graphical output. Lack of knowledge of software layers denies most users access to graphics.*

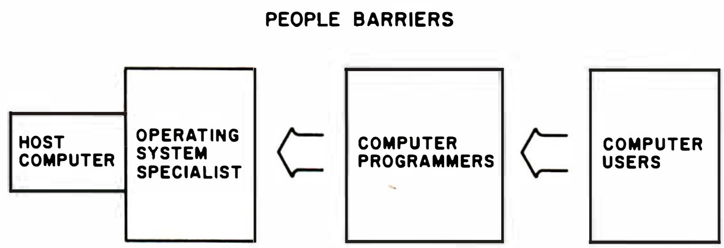


Figure 4: *Layers of people between the user and the computer form a barrier. This barrier is difficult to penetrate.*

Most users are not aware of how much hardware (see figure 2) there is between a computer terminal and the typical plotter. When problems occur, it is hard to determine if their source is hardware, software, or administrative (e.g., failure to activate a communications channel). When everything is working properly, the software forms the largest barrier to the computer user. For users to produce graphics on most systems, they must understand an installation's administrative procedures, operating system commands, editor commands, a programming language or the graphics vendor's software commands or both, and postprocessor commands that drive a particular graphics device (see figure 3). The 12-inch stack of documentation on the software layers forces most graphics customers to look for technical help.

The problem in finding technical help is that the user needs information from two different groups of people (see figure 4). One group is the operating system specialists who implement an installation's administrative procedures, install software packages, and determine the source of system problems. The other group is the computer programmers who use these software packages as components in computer models. Assembling a team to implement graphics for a simulation is thus expensive. The cost and complexity limit graphics to projects that have the required time and budget.

Producing Graphics on Microcomputers is Easy

The best approach to penetrating the hardware, software, and people barriers is to eliminate them partially or completely. This is exactly what microcomputers do. The following characteristics of micros make them accessible:

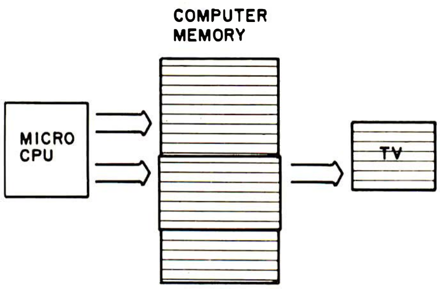


Figure 5: *Microcomputer systems keep an image of the graphics screen in memory. In raster graphics the television displays a section of the computer's memory that the computer can change easily at high speed.*

- Their operating systems do not require administrative procedures such as acquiring charge numbers, establishing user identification numbers, allocating disk space, or unlocking data security systems. Users just turn microcomputers on and use them.
- The operating systems are simple and easy to use. Thus the learning curve is short.
- All graphics hardware and software are integrated into one unit. This improves both reliability and reproducibility.
- Graphics is part of the built-in programming language (usually BASIC). Thus, the programmer can add graphics to his or her toolkit by simply learning a few extra statements or commands.
- Color graphics is usually built in. No additional translation process is required.
- The built-in character set is easy to change to a set that is relevant to the simulation. This allows the programmer to relate the graphics to the system being simulated.
- Built-in raster graphics makes pictures easy to change because the television picture is being redrawn many times per second. Changing a picture is fast and cheap. Animation is possible.
- The plotting capability of low-cost dot matrix printers allows one to readily obtain hard copies of the graphics screen. The user can have compact high resolution plots at the touch of a button.

The direct driving of displays (see figure 5) is what makes micros such powerful graphics machines. Direct drive means part of the computer's memory is devoted to maintaining the display. There is a mapping of memory onto the video display. Dot matrix printers with graphics capability can also access this section of computer memory to produce a hard copy of the display. What you see on the display is what you see on the printer, dot for dot. The contents of memory can also be stored on disk or transmitted over telephone lines. This means pictures can be stored, transmitted, and retrieved just like any other data.

Micros Do Have Limitations

Micros cannot replace expensive graphics systems costing over $20,000 because of limitations in speed, memory size, and display resolution. Typical microcomputers address between 64K bytes and 256K bytes of memory and have a maximum graphics resolution of 200 by 300 dots using one color. A typical minicomputer-based graphics system has more than two megabytes of memory and a graphics resolution of 1024 by 1024 dots using eight colors. Microcomputers have no graphics standards, and graphics is normally not transportable between micros, particularly ones from different manufacturers. Many small applications, however, do not need more capability than the micros provide and most applications require only an hour or two of programming time to produce pictures. Since the investment in programming time is small, users who switch computers are generally willing to rewrite graphics programs from scratch.

Users can learn about microcomputer graphics easily from hobby-level magazine articles and books. These articles and books give simple explanations and nice comparisons between graphics methods and systems. However, these sources do not help the user determine whether micros are suitable for a given application. The best approach is to employ common sense. Even if an application turns out to be unsuitable for microcomputers, the education gained will be valuable in software design for a larger system.

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Some Very Graphic Examples

The following examples demonstrate the kinds of graphics that micros can produce. One obvious application for this capability is in education where small-scale problems are studied in detail. However, any simulation that fits on a micro can use these graphic techniques.

Figure 6 shows a conventional bar chart. The resolution of this picture is 61 dots/in horizontally and 76 dots/in vertically. The maximum resolution of the printer is 120 dots/in horizontally and 216 dots/in vertically. It takes about 30 BASIC programming statements to produce this plot, representing about 30 minutes of programming effort.

Queuing problems are perfect targets for graphical output. It is much more informative to see queues evolve in time than to have only peak and average statistics as outputs. A good enhancement to the plot of figure 7 would be to place the results of many simulation runs on the same graph. This plot was produced with about 30 BASIC statements representing about 30 minutes of programming time.

Figure 8 is a snapshot of the state of a small bank simulation. Snapshots provide information in a form that is easy to understand. Snapshots can even be changed 60 times per second to produce real-time output. The user could then watch customers arrive at the bank and be served. If the waiting line gets too long, the user can easily add another teller and rerun the simulation. This kind of

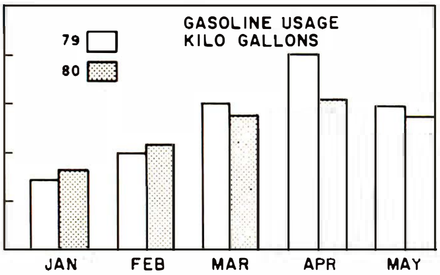


Figure 6: *Bar chart representation of simulation output. Conventional bar charts can be generated easily on a video-display terminal and reproduced on a dot matrix printer.*

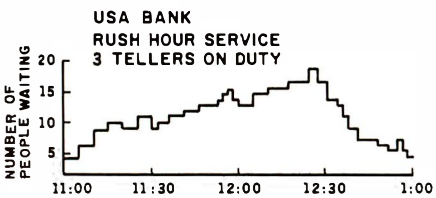


Figure 7: *Time plot of the state of a queuing system. The fine resolution of the graphics screen allows compact summaries of the results of a simulation.*

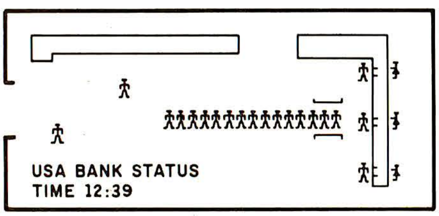


Figure 8: *Graphical representation of the current state of a queuing system. The ability to redefine the computer's character set simplifies the graphic representation of objects involved in a simulation.*

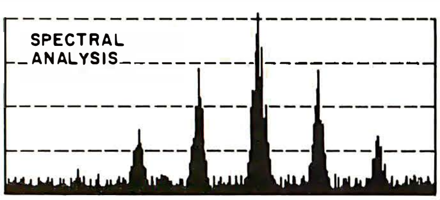


Figure 9: *Dot plot representation of simulation output. The dot plot capability of dot matrix printers allows printing of simulated displays from test equipment such as a spectrum analyzer.*

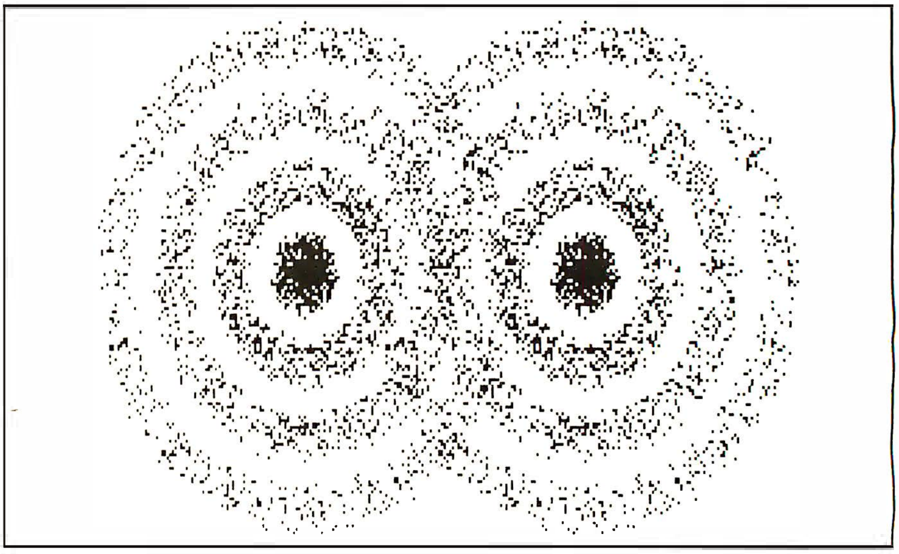


Figure 10: *Bit density plot of wave propagation. Two-dimensional wave propagation can be displayed using bit density plots on a grid of over 60,000 discrete points.*

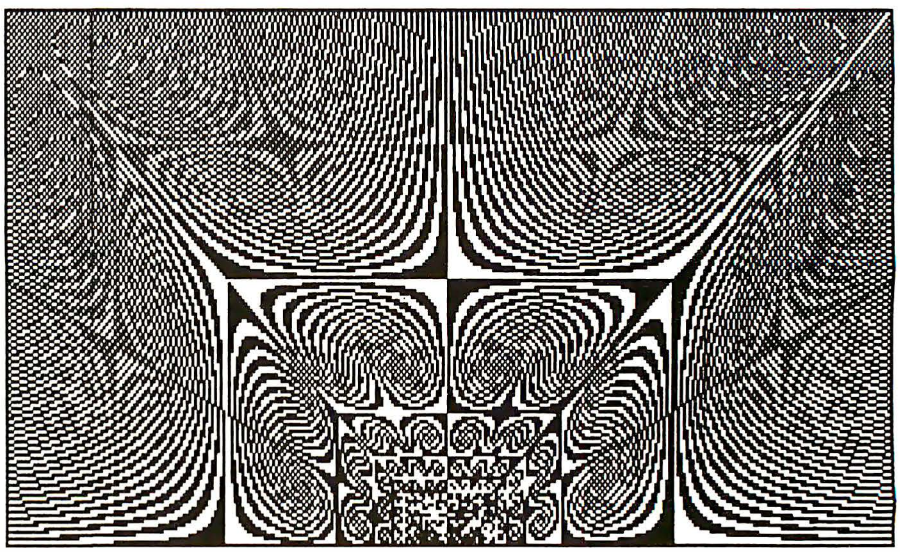


Figure 11: *Contour plot using varied dot densities. Some computer output is not numerical and only has meaning when displayed graphically as in this moiré.*

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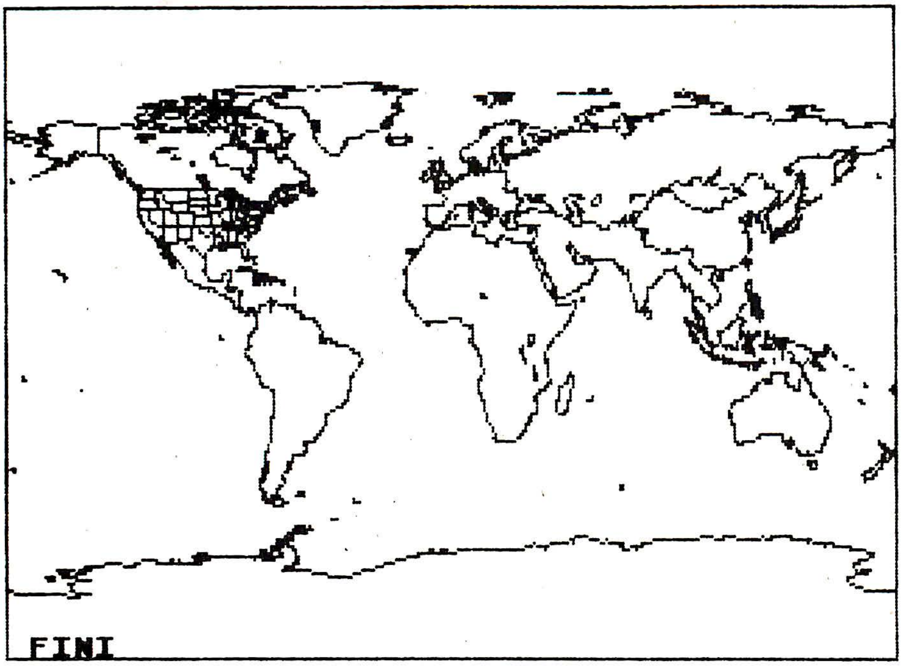


Figure 12: *Cylindrical equatorial projection. Geographic maps make good backgrounds for plotting results of demographic, economic, political, or meteorological simulations.*



Figure 13: *Cylindrical projection of North America. Geographic maps can be manipulated to produce the appropriate background for plotting simulation results.*

simulation has high credibility since anyone can observe and understand the behavior of the model.

In the analysis or simulation of electronic circuits, we could present results in the form that test equipment displays would produce for real circuits. This makes it easy to compare theoretical and actual circuit performance. Figure 9 shows an example derived from a spectrum analyzer. Simulation of test equipment displays is also useful in computer-aided instruction.

The resolution of raster displays is good enough to generate plots using dot densities to represent a third dimension. The entire plot in figure 10 was produced with the single statement PLOT X,Y. This plot is a good example of the fine resolution available on a $600 dot matrix printer. This plot took 2 hours to generate and 45 seconds to print. One exciting idea is to generate plots using red and blue dots and print them using color separation and color carbon paper. The plots would appear to be three-dimensional when viewed through red-green glasses.

The plot in figure 11 looks complex, but was generated by about 30 BASIC statements. It shows the effect on the eye of varying dot densities. In color, this plot is spectacular because of the blending that occurs when colors are plotted next to each other on a television. Even in black and white, one sometimes sees brown bands in the dot patterns. This kind of plot would be useful in producing contours or surface maps. It is another way to produce the illusion of three dimensions.

Figure 12 was produced with 100 BASIC statements that access a file of 8800 coordinates representing the surface of Earth. The program plotted this map in 12 minutes and printed it in 45 seconds. This program with data costs about $21.

Figures 12 and 13 were produced by the same program. Figure 13 demonstrates zooming in on a selected part of Earth's surface. Once these maps are plotted, they can be saved on disk and used repeatedly. It takes about 60 seconds to save or retrieve a map from disk.■

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This article was reprinted from the June 1982 *Simulation*—a publication of the Society for Computer Simulation, La Jolla, CA.

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1



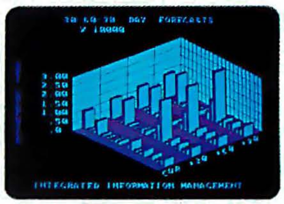
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Going Further

A compendium of conferences, organizations, books, and software for simulationists

by Charles A. Pratt

Simulation is one of the oldest and best established applications for computers. Engineers in the aerospace field began work on simulation with analog computers in the early 1950s. As a result of this relatively long history, in computer terms, simulation has developed a body of literature and a methodology shared by few other application areas. The conferences, organizations, books, and software list that follows should get you off to a good start on the subject.

Conferences

Until recently, simulationists were just not interested in anything except very large computers, because the size of their programs was far beyond the capacity of the first microcomputers. This sentiment has changed radically in the last few years due to the increased capacity of microcomputers.

The first real sign of this acceptance was the conference called Modeling and Simulation on Microcomputers, held in San Diego by the Society for Computer Simulation (SCS) in January of 1982. Initiated by Dr. Lance A. Leventhal (at the time the technical editor for SCS's monthly journal, *Simulation*) and me to encourage communication between the experienced simulationist and people working with microcomputers, it remains the only existing conference on this specialized subject. Dr. David M. Chereb responded to the need by becoming chairman of that first conference. At that meeting, he presented an econometric model of the U.S. that ran on a 48K-byte TRS-80. The variety of applications presented in 1982 astounded all of us. Some of those applications involved computational fluid dynamics, a model of the educational system in Mexico, a weather-impact model, a physiological model, a model of army mobilization, and robot kinematics.

The second year of the conference, 1983, continued with the presentation of several serious engineering simulations on microcomputers. Several languages specifically designed for modeling on microcomputers were introduced: Micro-Sim, Micro-Passim, Tabletop Simscript, Tutsim, and Micro-Rsmm.

The titles of some of the papers planned for the 1984 conference further demonstrate the diversity of uses for simulation:

•Microplan: A Microcomputer-Based Traffic Control Plan Generator
•Can an Early Retirement Incentive Program Pay for Itself?
•Transit: Route Scheduling and Performance Optimization
•Microcomputer Modeling and Simulation in Government Tax Revenue Estimation
•Microcomputer Seismic Signal Simulation
•M-CUPS: A Chemical Process Simulation Written in UCSD Pascal
•Consistency of Price Cycles in the Dow Jones Industrial Average

Two other conferences covering simulation on both microcomputers and larger machines are the Summer Computer Simulation Conference (Boston, July 23–25, 1984) and the Winter Simulation Conference (Dallas, November 28–30, 1984). Contact the Society for Computer Simulation, POB 2228, La Jolla, CA 92038, (619) 459-3888 for more information on these conferences.

Organizations

The Society for Computer Simulation is the only organization made up exclusively of people interested in computer simulation. The SCS has several active regional councils that have one or more meetings each year.

The IEEE Computer Society has a simulation technical committee that publishes the quarterly journal, *Modeling*. The society can be contacted at 1109 Spring St., Suite 300, Silver Spring, MD 20910, (301) 589-8142. The SIGSIM group (Special Interest Group—Simulation) of the Association for Computing Machinery (ACM) can be contacted at 11 W. 42nd St., New York, NY 10036, (212) 869-7440. There are several international simulation organizations:

International Association for Mathematics and Computers in Simulation (IMACS)
(has representatives in many countries)
c/o Prof. A. W. Bennett
Dept. of Electrical and Computer Engineering
Clemson University
Clemson, SC 29632
U.S.A.

Scandinavian Simulation Society (SIMS)
Technical Research Centre of Finland
VTT/Sah, 02150 Espoo, Finland

Japan Society for Simulation Technology (JSST)
c/o Dr. Michio Nakano
Dept. of Control Engineering
Tokyo Institute of Technology
2-12-1 Oh-okayama, Meguro-ku
Tokyo 152, Japan

Association Francaise d'Intelligence Artificielle et des Systèmes de Simulation (AFIAS)
211, Rue Saint-Honoré
75001 Paris
France

Dutch Benelux Simulation Society (DBSS)
E. G. H. Kerckhoffs
Delft University of Technology
Dept. Of Mathematics/Informatics
Julianalaan 132
2628 BL Delft, The Netherlands

Arbeitsgemeinschaft für Simulation (ASIM)
Prof. Dr.-Ing. W. Ameling
Lehrstuhl für Allgemeine Elektrotechnik
und Datenverarbeitungssysteme
RWTH Aachen
Schinkerstrasse 2
D-5100 Aachen, West Germany

Microcomputer Software

Item Name	Brief Description	Contact	Computer	Operating System/ Other Software Required	Peripherals Required	Cost
ACES: All-Purpose Continuous Equation Simulator	Graphics solution to over 100 coupled first-order nonlinear differential equations using powerful fourth-order integration routine. Over 100-page manual.	Jay Wilson Modulo 2 Company POB 58781 Tukwila, WA 98188 (206) 271-9258	Apple II work-alike	DOS 3.3	disk drive	$199.95
ASSE: Ada Simulation Support Environment	Package system for combined discrete-event activity scanning and process interaction (transaction flow) modeling in Ada.	Dr. Heimo H. Adelsberger Institut für Statistik Augasse 2-6 Vienna, Austria A-1090 347541, ext. 757		CP/M	64K bytes, screen, printer	$5000
EZQ Differential Equation Solver	Solve differential, difference, and algebraic equations on an Apple II with graphical and tabular output.	Acme Software Arts Box 6126 Evanston, IL 60204 (312) 942-6412	Apple II	DOS 3.3	64K bytes of memory, one disk, printer optional	$79.95

Table 1: *The Society for Computer Simulation's latest list of simulation software available for microcomputers, originally published in the SCS journal* Simulation. *Contact the manufacturer for definitive data.*

Item Name	Brief Description	Contact	Computer	Operating System/ Other Software Required	Peripherals Required	Cost
H-Champ	Helmsman's application environment software package, supporting users of hard disk, multiuser micros, and Unix minis.	Helmsman Systems Inc. Mr. Silverstein 1030 S. Winchester #205 San Jose, CA 95128 (408) 246-8300	Z80, 8080, 8085, 8088, 8086, 68000, Z8000, etc.	CP/M 8-bit, CP/M 16-bit, MS-DOS 2.0, and Unix		$695
ISG: Interactive Scientific Graphics	Package of UCSD Pascal procedures, with interactive features, plots sets of functions with full labeling.	Thomas H. Bleakney 18537 Arrow Hwy. Suite D-105 Covina, CA 91722 (213) 339-8716	Apple II, II Plus	Pascal 1.1	language card or other 16K-byte RAM card	$95
ISL-Apple	Ideal for educators. Solves nonlinear differential equations up to 10 times faster than Apple BASIC. Uses game paddles and graphics.	R. D. Benham 5312 W. Tucannon Kennewick, WA 99336 (509) 783-3829	Any Apple II with 48K bytes of memory	Apple DOS version 3.3	disk drive	available upon request
m-CPS: Chemical Process Simulation	m-CPS is a hydrocarbon simulation using the SRK equation of state. Includes a database of over 60 compounds. Free format input file.	Ofelt and Associates 8007 Oak Moss Dr. Spring, TX 77379 (713) 376-3614	Apple II Plus/IIe, 64K	Pascal	two disk drives, optional printer	$250
Micro-Dynamo System Dynamics Modeling Language	Micro-Dynamo compiles and simulates complex models of cause-and-effect relationships over time. It lets you create your model and specify what variables are printed and plotted —without complicated format statements. Interprets model internally to produce both tabular and plotted results.	Software Sales Addison-Wesley Publishing Company Inc. Jacob Way Reading, MA 01867 (617) 944-3700	Apple II, IBM PC	Pascal operating system	two disk drives, color or b/w monitor, printer recommended	$245
Micronet	A network-based discrete-event language that operates as a simulation system for microcomputers.	Pritsker & Associates Inc. POB 2413 A West Lafayette, IN 47906 (317) 463-5557	Apple II Plus, Apple IIe, IBM PC, IBM PC XT	various		$2500
Micro-Passim	A simulation support package for combined discrete-event and continuous models in UCSD Pascal. Both process interaction and event scheduling world views are implemented. Example models included in the documentation.	Dr. Claude C. Barnett Physics Dept. Walla Walla College College Place, WA 99324 (509) 527-2881	Apple II and III, PDP 11/23, IBM PC, etc.	UCSD Pascal	disk drive	$125

Item Name	Brief Description	Contact	Computer	Operating System/ Other Software Required	Peripherals Required	Cost
Micro-Sim	Simulation package for simulating queuing networks. Has graphics and is interactive.	Stewart Hoover 36 Evergreen Rd. Sudbury, MA 01776 (617) 443-9023	Terak, Apple	UCSD Pascal	some graphics capability	$50
Scheduling Simulator	A system especially designed to simulate the orders being processed in a job shop environment such that trial schedules may be run and analyzed.	Lionel Poizner 81 Millwick Dr. Weston, Ontario Canada M9L 2R4 (416) 781-F.A.S.T.	Apple II and other such microcomputers	DOS 3.3	four disk drives, printer	$535
SIMAN simulation package	General-purpose simulation language with special manufacturing systems features. Three modeling orientations available, graphical and statistical output.	Dennis Pegden System Modeling Corporation 226 Highland Ave. Suite B State College, PA 16801 (814) 238-5919	MS-DOS microcomputers	Standard FORTRAN	190K bytes of RAM	$900
Sim-By-Int	"Simulation-By-Interview" . . . Program examples of code for user-interactive definitions of dynamic systems.	G. R. Marr Jr. POB 143 Little Silver, NJ 07739 (201) 747-2606	various	CP/M, UCSD Pascal, dBASE II	KB/CRT/printer	$5
Simscript 11.5	Language for computer modeling.	C.A.C.I. 12011 San Vicente Blvd. Los Angeles, CA 90049 (213) 476-6511	IBM PC			
SMP: System Modeling Program	A continuous-time system simulation language with direct equation input for the Apple computer.	Dr. Steven E. Reyer 8664 N. Pelham Pkwy. Bayside, WI 53217 (414) 351-2087	Apple II Plus, 48K	DOS 3.3	optional printer	
TDKIN: Three-Dimensional Kinematics	Computer program that assembles and solves the equations resulting in the solution of kinematics of three-dimensional mechanisms.	Harry W. Townes 514 North 10th Ave. Bozeman, MT 59715 (406) 994-6297	Microcomputers or mainframes written in FORTRAN 66	FORTRAN compiler or CP/M	optional printer	variable; depends on purchase of source code or CP/M relocatable files
Transit	Estimates and traces future performance of transport systems.	Y. J. Stephanedes 500 Pillsbury Dr. SE Minneapolis, MN 55455	IBM PC, Apple II	UCSD Pascal	screen for graphics	$100
Tutsim	Interactive simulation program for continuous dynamic systems on mini- and microcomputer systems with block diagram and bondgraph model input.	Applied i 200 California Ave. Palo Alto, CA 94306 (415) 325-4800	Apple, CP/M-based, PDP-11, LSI-11, IBM PC	variable according to computer used	graphical output	$350–$2000

Books

Although many good books on simulation are available, few cover microcomputers. Tab Books Inc. (Blue Ridge Summit, PA) published two in 1983 that can be very helpful. A good introduction is *Learning Simulation Techniques on a Microcomputer Playing Blackjack & Other Monte Carlo Games* by Pat Macaluso, for $10.95. It covers a good deal of the terminology and concepts used in designing models. The title may mislead you; blackjack is used as an example, but the other program is a simulation that can be applied to business ventures. (See Mr. Macaluso's article on page 179.) The other Tab Book, *Forecasting on Your Microcomputer* by Daniel B. Nickell ($14.95), concentrates on forecasting and uses modeling as one of several techniques. A chapter on the mathematical principles involved is written in a way that makes them clear even to one without a math background.

For further study of simulation, one of the best textbooks I've seen is *Simulation Modeling and Analysis* by Averill M. Law and David W. Kelton (New York: McGraw-Hill, 1982). It provides a good understanding of simulation as art and science and can start the beginner on an established methodology.

A list of books in this specialty would be incomplete without mentioning the publications that result each year from the SCS conference mentioned above. Both the conference and the books are titled *Modeling and Simulation on Microcomputers*. A new book is published each year and is available for $20 from the Society for Computer Simulation. Each contains a description of a variety of models, usually without code. ■

Charles Pratt has served as executive director of the Society for Computer Simulation (POB 2228, La Jolla, CA 92038) since August of 1980. He has a bachelor's degree in economics from Guilford College in North Carolina.

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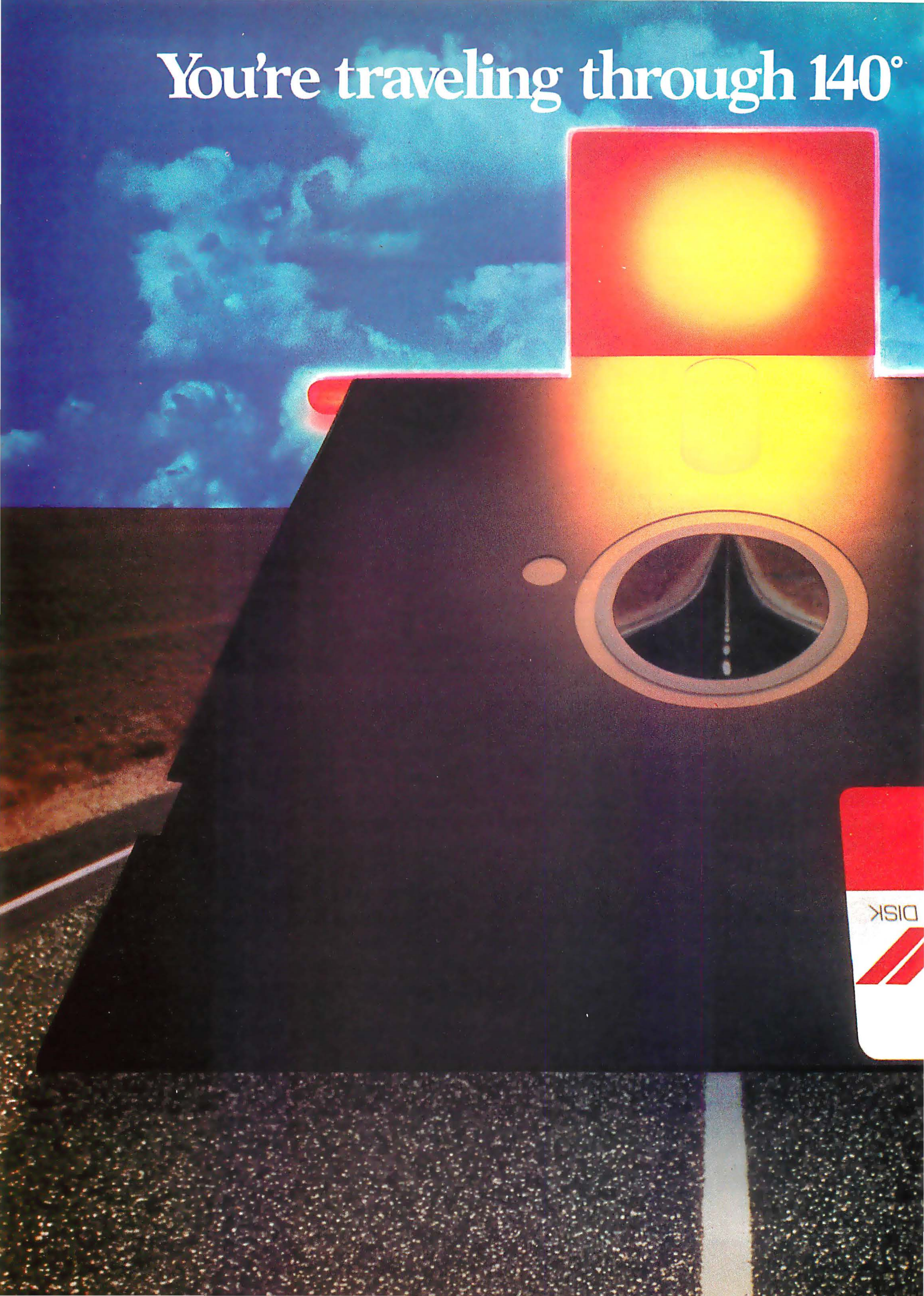
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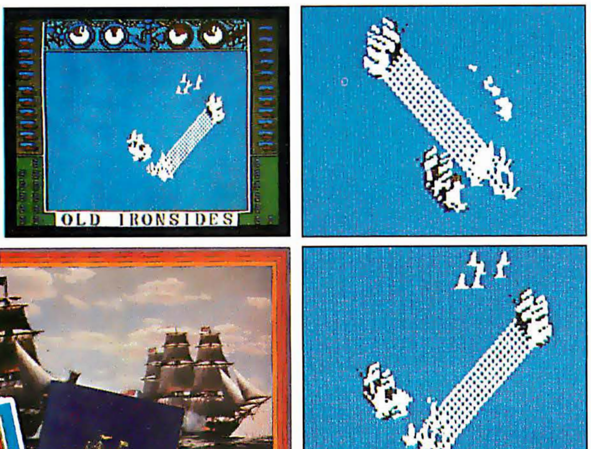
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Reviewer's Notebook

by Rich Malloy

The really big item this month is the Tandy TRS-80 Model 2000, which is described in an article on page 306 of this issue. From the brief experience I've had with the 2000, I have been much impressed. Let's hope that Radio Shack makes available a good technical reference manual so that the hackers can turn it into an even better machine.

Wang's Professional

Lately, we've received a few systems that are obviously not meant for hackers. Most prominent among them is a hard-disk version of the Wang Professional Computer (see Elaine Long's review of the floppy-disk version on page 360 of the December 1983 BYTE). This is a fairly well designed system. In fact, I used it to write this month's column, but not without some difficulty. This machine takes some getting used to. The keyboard, in particular, has a touch that is a little too light. Also, it's hard to make the machine work correctly with a non-Wang printer. But overall the system is pretty good.

I particularly like the monitor support arm, which allows the monitor to hover a few inches over your desk. This should be great for people like me whose desks are already covered with a few inches of various materials.

Again, although it is a fairly powerful machine (it has an 8-MHz 8086 microprocessor), the Wang PC is not meant for hackers. It is clearly designed for the office. And although it is disk-compatible with the IBM PC, you will probably have to buy all your software and accessories from Wang itself. The software selection is of good quality. We have Multiplan, 1-2-3, TK Solver, and version 2.0 of Wang's word processor, which is supposed to be identical to Wang's dedicated word processors. But the number of packages available is rather small. Also, the user-friendly menu system that leads you through MS-DOS version 2.0 can drive experienced computerists batty. The Wang PC is probably a good machine for your cousin the lawyer.

DEC's Rainbow

In response to a previous column, Digital Equipment Corporation has sent us a new version of its Rainbow, this one called the Rainbow 100 Plus. I can tell because it came with a little plastic sticker saying "100 Plus" that we're supposed to stick onto the front of the machine.

Also, we've finally received a copy of MS-DOS for the Rainbow, with a Format program included. Now we can format our own disks, but few other MS-DOS machines can read them. The Rainbow uses single-sided, quad-density disks. Fortunately, the Rainbow can read other MS-DOS disks, but only if they're single-sided. And in my experience, it can't read all the files on a single-sided PC-DOS disk all the time.

As for software compatibility, this machine cannot run many of the IBM PC programs. You will probably have to buy most of your software from DEC. And as for expansion slots, after you install a hard-disk drive, some extra memory, and a color graphics board, there are no slots left.

The Rainbow is a slick, good-looking office computer with a number of nice features. But, like the Wang PC, this is not a hacker's machine. In time, however, the Rainbow will probably evolve into a very impressive system.

The Compaq Plus

Another recent entry into our computer room is the Compaq Plus, the 10-megabyte version of the original IBM PC clone. This machine sports a 3½-inch hard disk, which reportedly is surrounded by a sizable cushioning system. This, too, is an office machine, but it is built to travel.

Unlike the Wang and the Rainbow, the Compaq should have no problems with any IBM PC software. The Compaq has traditionally scored very high in most IBM PC-compatibility tests, and at $4995 it represents a serious alternative to the IBM PC XT.

The Tava

We also received the Tava computer, another IBM PC clone, but with Asian roots. The Tava has been raising a few eyebrows by advertising a price of $995. But before you sell your shares of Big Blue, you should note that that price doesn't include any disk drives or a monitor. Two double-sided disk drives with a controller will set you back an additional $670.

As for performance, our Tava was not completely without problems. First, we couldn't get it to turn on because its fan was stuck. Then we didn't have an operating system, or a serial port or parallel port for that matter. We tried PC-DOS, and most IBM programs ran without a problem. Some programs, however, didn't recognize the Tava's color graphics adapter as a bona fide board. Tava sent us a parallel port (just a connector that plugs into the motherboard), and the serial ports (there are two) should arrive any day.

I really like the Tava's documentation—a single piece of paper saying, in effect, that you should insert a disk into one of the drives and turn the machine on.■

Rich Malloy is BYTE's product-review editor.

Compupro's System 816/C and System 68K—the Two and Only

Take a look at Compupro's new reversibles—they're 8085/8088 on one side and 68000 on the other

by Ed Teja

Compupro's two new computer systems, the System 816/C and the System 68K, are based on the same S-100 bus enclosure, and they both use the same memory and I/O (input/output) boards. When loaded with the same options, they differ only in their microprocessors. The System 816/C uses an 8-bit, 6-MHz 8085 microprocessor and a 16-bit, 8-MHz 8088 microprocessor. The System 68K, on the other hand, uses a 16-bit, 4- or 8-MHz 68000 microprocessor. The systems come with different versions of CP/M.

Both systems feature two solidly built metal enclosures, the Desktop Enclosure 2 and the disk-drive enclosure. The Desktop Enclosure 2 houses a 20-slot motherboard, the central processing unit, memory, I/O boards, a constant-voltage power supply, a line filter, and a large fan. The disk enclosure contains the disk drives and another fan. Photos 1 and 2 show the front and back of the enclosures, respectively.

Each system costs $8995—not expensive as business systems go, but definitely not economical enough for most hobbyists. Besides the hardware and software, though, you also get repair service under Xerox's Americare program. This program gives you free on-site service for one year if you are within a 100-mile radius of one of Xerox's 82 service centers. Outside that radius, you either pay a service charge for on-site work or you can take the system into a service center. This bundled-in service program beats any other available form of technical support hands down and makes the package a better risk for businesses. That is, it's a better risk if these are the right computers. Let's take a closer look at the machines and see.



Photo 1: *The front of Compupro's System 816/C computer. The System 68K looks the same. (All photos were taken by Carey Hillhouse.)*

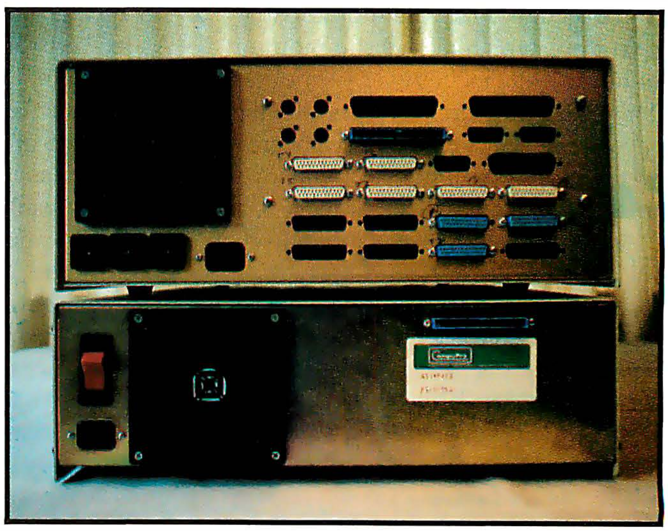


Photo 2: *The rear of the System 816/C. The system operator (user 0) plugs into the bottom right connector. The wide connector at the top center connects to the disk drives.*

System 816/C Hardware

The heart of the System 816/C is the 8085/8088 central processing unit, shown in photo 3. This board allows the computer to run either 8-bit or 16-bit CP/M programs at high execution speeds.

Most of the System 816/C's I/O functions are handled by the System Support 1 and Interfacer 3 boards. The System Support 1 board provides an RS-232C port and most of the I/O support features, such as the clock/calendar, dual-interrupt controllers, and triple interrupt timers. The Interfacer 3 board furnishes eight fully programmable asynchronous serial channels to which the user's terminals are connected. The System 816/C comes configured to support three users; however, you can expand it to handle 15 users. There are two parallel ports: one handles the endless variety of Centronics/Epson-type printers, while the other is an untyped port to use as you will.

The system comes with 512K bytes of CMOS (complementary metal oxide semiconductor) RAM (random-access read/write memory) dwelling on two of Compupro's RAM 22 cards. These cards act as a byte-wide memory for 8-bit systems and then switch automatically to a word-wide configuration for 16-bit operation by reading the state of the SXTRQ signal on the S-100 bus. A single DIP (dual in-line package) switch assigns each memory board a starting address that is a multiple of 256K bytes, within the 16 megabyte address space specified by the IEEE-696 standard. If you want to add memory, simply buy additional RAM 22 cards ($2495 each), set the switch, and plug the boards in. You don't have to reconfigure the system—an autoconfiguration routine takes care of that.

Compupro designed its RAM 22 cards especially for use with 8086/8088 processors at speeds exceeding 10 MHz. In particular, the RAM 22 is suitable for DMA (direct memory access) operations. DMA is critical in multiuser systems, because you can't expect a processor to handle multiple users and I/O as well.

For more permanent storage, the System 816/C comes with two 8-inch, double-sided, double-density floppy disks in a separate cabinet. The system I used came with Qume Trak 842 drives. Together, the floppy disks give you 2.4 megabytes of storage, formatted in 1024-byte sectors. These drives also read single-sided, single-density disks.

Compupro's Disk 1 board handles the disk operations and houses the phantom boot EPROM (erasable programmable read-only memory) that can handle eight different processors or boot routines. The board furnishes fully arbitrated DMA data transfers that can cross 64K-byte boundaries.

An Intel 8272 floppy-disk-controller chip is the heart of the disk-controller board. According to the manual, this lets the controller format disks with a true IBM 3740/System 34 disk format. But this presents a problem if you try to use the controller with a disk that was formatted using a 1791 disk-controller chip, because the 1791 inserts a byte of zeros immediately after the header CRC (cyclic redundancy check) bytes. The zeros can confuse the 8272. I didn't have a 1791-formatted disk with which to test this, and it isn't clear what the confusion ultimately does. But this could lead to some interesting service calls for the Americare folks.

One of the System 816/C's most powerful features is its optional M-DRIVE/H solid-state disk emulator, shown in photo 4. A solid-state disk emulator configures and uses RAM as if it were a disk drive, but without the slow access times inherent in a disk drive. Even the 30- to 65-millisecond average access times offered by many Winchesters seem slow next to solid-state disk access times.

The system I used came equipped with a single 512K-byte M-DRIVE/H board. You can add 4 megabytes worth of RAM disk (on eight boards) if you need it. Compupro's software recognizes the presence of the RAM disk

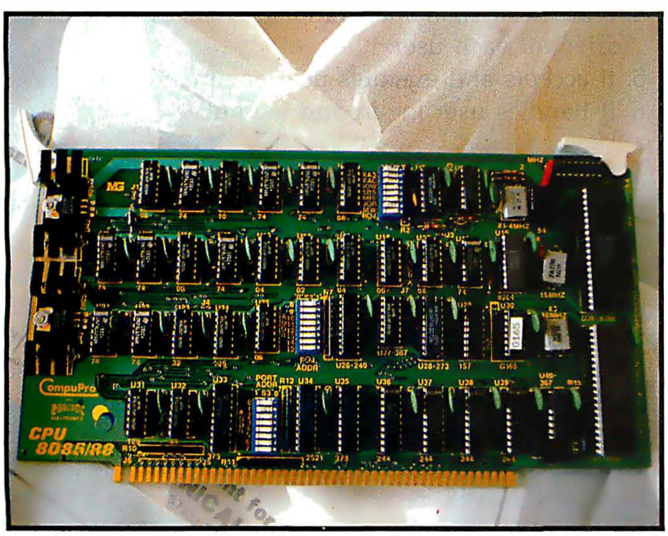


Photo 3: *The 8085/8088 central processing unit of the System 816/C.*

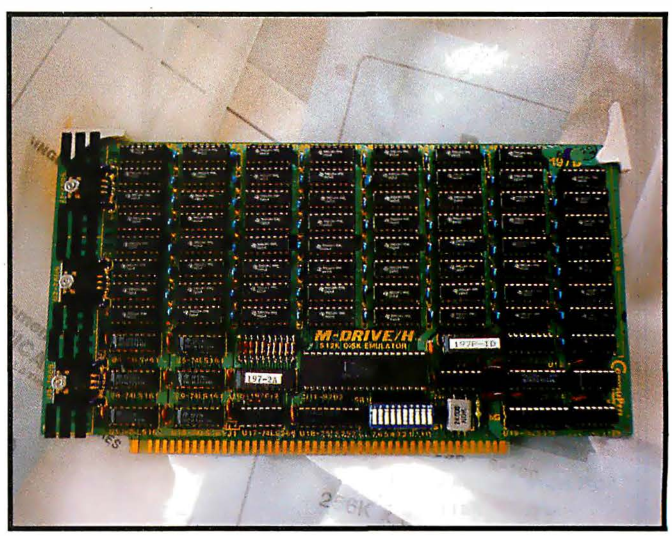


Photo 4: *The M-DRIVE/H solid-state disk emulator.*

At a Glance

Name
System 816/C

Manufacturer
Compupro
3506 Breakwater Court
Hayward, CA 94545
(415) 786-0909

Price
$8995

Processors
8085 and 8088

Memory
512K bytes of RAM

Data storage
Two double-sided, double-density 8-inch floppy drives furnishing up to 2.4 megabytes of storage

Hardware needed
Terminal, printer

Software supplied
CP/M-80, CP/M-86, MP/M 8-16, Supercalc-86, dBASE II

Options
512K bytes of solid-state disk ($1895)

Audience
System developers and professional users

At a Glance

Name
System 68K

Manufacturer
Compupro
3506 Breakwater Court
Hayward, CA 94545
(415) 786-0909

Price
$8995

Processors
68000

Memory
512K bytes of RAM, 1.5 megabytes of solid-state disk

Data storage
Two double-sided, double-density 8-inch floppy drives furnishing up to 2.4 megabytes of storage

Hardware needed
Terminal, printer

Software supplied
CP/M-68K, C Compiler, MAPFORTH

Audience
System developers and professional users

and treats it as drive M when you boot the system. Addressed as two I/O ports, the board takes up none of the system's 16 megabytes of address space. The board formats as 504K bytes of disk space. Although not cheap ($1895 per 512K-byte board), this is one of the few system-performance options that carries its own weight. The RAM disk can make the difference in whether the System 816/C, or any other computer, works fast enough for your application. It's hard to imagine using a powerful computer system such as the 816/C without a solid-state disk of some sort. The disk-access bottlenecks that naturally occur when several users share the same resources would eliminate any advantage that the system offers. You'd be better advised to buy individual desktop computers for each user than one powerful system that doesn't offer a solid-state disk.

System 816/C Software

Each System 816/C comes with CP/M-80, CP/M-86, MP/M 8-16, Supercalc-86, and dBASE II. These programs should prove adequate for the business that is just becoming computerized. If they aren't, other applications programs are available from many sources.

To take full advantage of the System 816/C, you'll want to use the multiuser MP/M 8-16 operating system. This is Compupro's proprietary implementation of Digital Research's MP/M-86. MP/M 8-16 lets you run 8-bit and 16-bit programs simultaneously, and it is compatible with all CP/M and MP/M operating environments.

To make the user interface—called the Terminal Message Process (TMP)—more useful, Compupro has modified it as a system shell. This shell has six functions:

1. It makes terminal, printer, user, and drive assignments during log-in.
2. It lets the system operator make changes in printer default assignments.
3. It lets the system operator make changes in the user default number.
4. It lets the system operator make changes in the default drive for each user.
5. It accepts and executes user command lines.
6. It handles user log-in and log-out.

The system operator (user 0) can reset any of these characteristics every time the system is booted. In this way, the system operator controls which users have access to which system resources. You can give every user access to every resource if you want, but you might want to protect certain files or other resources.

Unfortunately, MP/M isn't the answer for all multiuser applications. If you are running a manufacturing program that requires every operator to have access to files on a record-by-record basis, MP/M can't handle the job, because it has no record-locking feature. On a file-by-file basis, however, it performs well. MP/M 8-16, in particular, is convenient because it allows one user to run an 8-bit program at the same time that another user is running a 16-bit program.

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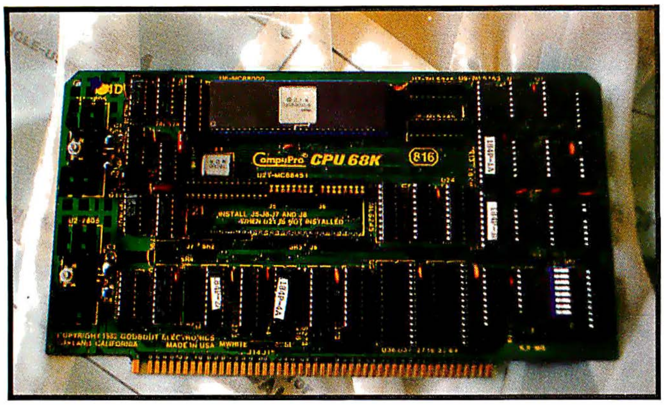


Photo 5: *The System 68K's central processing unit's 68K-byte board.*

The only problem with this software package is that you'll have to format and copy all of your disks under CP/M. For some unexplained reason, the Diskcopy utility doesn't run under MP/M, but that is a minor inconvenience.

System 68K Hardware

The only real difference between the System 816/C and the System 68K is the central processing unit's 68K-byte board, shown in photo 5. As the name implies, this board is an S-100 processor card that uses the 68000 processor. It upgrades any IEEE-696/S-100 computer system from 8 to 16 bits. The 68000 runs at either 4 or 8 MHz (standard at 8 MHz) and works with a variety of 8- and 16-bit memory and peripheral devices. Another version that runs at 5 or 10 MHz is available. The board furnishes two sockets for up to 16K bytes of ROM (read-only memory), a jump-on-reset feature, and it even has provisions for an optional memory-management unit. A 24-bit addressing scheme accommodates up to 16 megabytes of memory, including a 64K-byte block of I/O addresses.

For $695, you can add the central processing unit's 68K bytes to your System 816/C. You simply unplug the old processor board, plug in the new board and change a few DIP switch positions, and change a jumper on the Disk 1 card.

Once you've made these changes, you've turned your System 816/C into a System 68K. Buying the System 68K does have one advantage over upgrading a System 816/C, however—it already comes with 1.5 megabytes of M-DRIVE/H.

System 68K Software

Compupro's version of CP/M-68K comes on two disks. The first disk contains CP/M-68K and its C compiler configured for the System 68K. The second disk gives you everything you need to create a customized system, including the source, library, and submit files needed to modify the BIOS (basic input/output system) to meet your system requirements. Thus, one System 68K can act as a development system for other CP/M-68K systems.

The CP/M-68K operating system that Compupro provides requires at least 256K bytes of RAM addressed at 0; a floppy-disk drive connected to the Disk 1 board (addressed at hexadecimal C0); a terminal set for 9600 bps (bits per second) with an 8-bit word length, no parity, two stop bits, and, to accommodate system I/O, Compupro's System Support 1 board with its I/O address set to hexadecimal 50.

You also get a third disk containing another standalone system, MAPFORTH. The system includes the operating system, a FORTH compiler and interpreter, and a variety of precompiled utilities written in FORTH. You can't use FORTH and CP/M-68K together, but at least for the moment you can write FORTH programs. Later, these should port over to other operating systems with little problem.

Using CP/M-68K proved straightforward. The only bug appears in the Diskcopy utility. You can only Diskcopy a single-sided disk to a single-sided disk. You can copy individual files to a larger disk with PIP (peripheral-interchange program), but you cannot use the Diskcopy routine. This problem occurs with the System 816/C version of CP/M, too.

Performance

"A High-Level Language Benchmark" (September 1981 BYTE, page 180) and "Eratosthenes Revisited: Once More through the Sieve" (January 1983 BYTE, page 283) compared the computational speed of a variety of 8- and 16-bit computer systems. The benchmarks with which the comparisons were performed were all written in high-level languages, such as FORTRAN, FORTH, Pascal, and C. Digital Research's CP/M-68K operating system comes with a C compiler, so I was able to make a direct comparison with the machines already reviewed.

In the September 1981 article, the fastest execution time recorded was logged by a 68000 programmed in assembly language. It executed the program in 1.12 seconds. A PDP-11/70 running C came in second place, executing the benchmark in 1.52 seconds. Also in the 4.00 seconds-and-under category was an 8086 (assembly language), a PDP-11/70 running NBS Pascal, a Z8000 running Onyx C (Unix), and a 5-MHz 8088 programmed in assembly language. According to my testing, the System 68K should fit in next, because it ran the benchmark in 4.5 seconds, tying for seventh place with a PDP-11/60 running NBS Pascal. A PDP-11/40 running C placed ninth with an execution speed of 6.1 seconds. This puts Compupro in the top third of the 26 16-bit machines tested (25 reported in the article, plus the Compupro).

The much more comprehensive 1983 survey tested 17 different 68000-based machines, with the same benchmark used earlier. Four of these executed the program in less than 4.5 seconds, the fastest being an 8-MHz machine programmed in assembly code. Only one other 68000-based machine ran faster than 4.0 seconds—a machine programmed in SMPL that ran in 2.6 seconds.

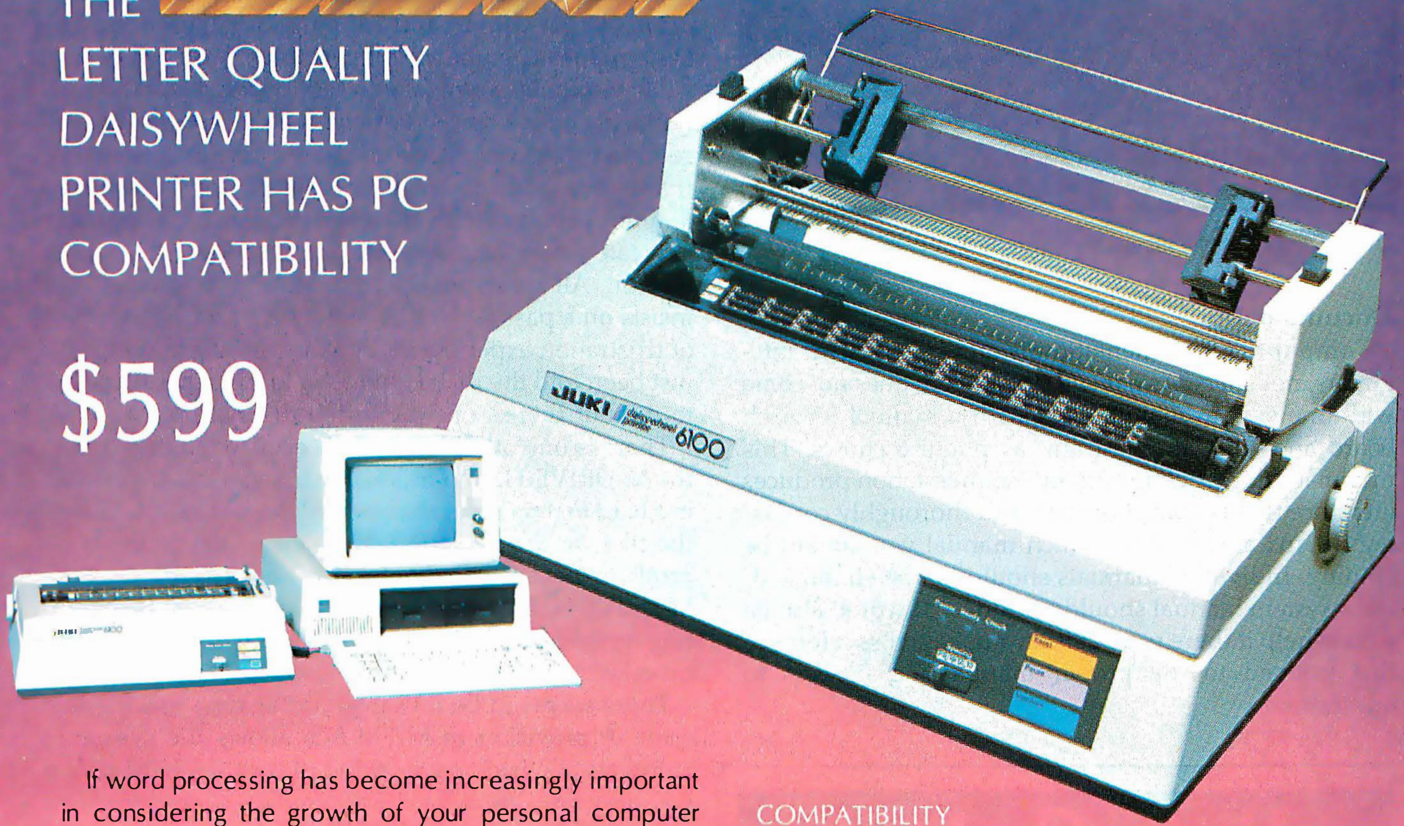
In short, the Compupro System 68K compares favorably with other systems. It isn't the fastest or most efficient, but it is competitive.

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Photo 6: *The stack of manuals that you get with either computer.*

Documentation

Compupro's documentation is aimed at system integrators, not users. As a result, the system does not come with one system manual, but with a manual for each board and software program, as photo 6 shows. This miasmatic approach to system documentation produces literature that is both thorough and thoroughly confusing. It isn't always clear which manual you should be reading. Individual manuals should not be eliminated, but a system manual should be added. It would also be a great help if there were at least a user's cross reference that pointed to the proper manual for answers to questions.

Using the System

In spite of the documentation problem, the system proved simple to configure and begin using. There really isn't much to know, and there is plenty of information in the *MP/M 8-16 Technical Manual and Installation Procedures* to get you up and running in half an hour. The system doesn't come with a terminal, but I pressed an Adds Viewpoint terminal into service and it worked well.

Playing with a new system with no regard for the consequences can uncover some interesting anomalies. By trying thousands of things that didn't work, I discovered a minor problem with the shell program; it is possible to create a user interface that doesn't allow any users to sign on. All passwords become invalid, but the system insists on a password. The situation produces the kind of frustration experienced by Wordstar users who have just been told the disk is full. You know what you want to do, but there's no way to tell the system.

There is one other trap that is easy to fall into. Using the M-DRIVE/H is so much like using a fast disk drive, it is hard to remember that, when you turn off the power, the files on the M-DRIVE/H go away. Rebooting is no problem, because the boot routine doesn't reformat the M-DRIVE/H; but turning the power off without first putting the files you want to keep on a real disk is a definite mistake.

There seems to be no safeguard against making that error. A provision in MP/M 8-16 allows the system to automatically back up working files to the hard disk if you have one, but it has nothing that will rescue a user from the folly of turning off the power with data on the M drive. You could use the Sched (schedule) utility to cause the system to PIP all of the files from drive M to one of the floppy disks periodically, but that might prove disconcerting to unsuspecting users.

Conclusions

Although the System 816/C has a fairly high price tag ($10,890 with M-DRIVE/H), in a multiuser application it provides high performance at only about $3600 per user. Converting the System 816/C to a System 68K is simple and takes but a few minutes. And the System 68K's performance compares favorably to that of other 68000-based computers and PDP-11/60 minicomputers. The M-DRIVE/H solid-state disk emulator eliminates disk-access bottlenecks and the dual processor scheme of the System 816/C works well and is totally transparent to the user. The Americare program makes either computer a good bet for business and professional users. On the minus side, the System 816/C needs a Diskcopy routine that will run under MP/M. But the MP/M 8-16 shell will let you create exactly the system you want for each user. Well designed and executed, both computers are easy to love.■

Ed Teja (238 Swift St., Santa Cruz, CA 95060) writes extensively about computers and peripherals. His latest book, A Designer's Guide to Disk Drives, *will soon be published by Reston Publishing Company Inc.*

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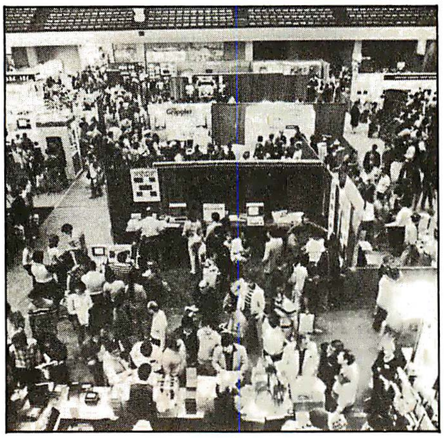
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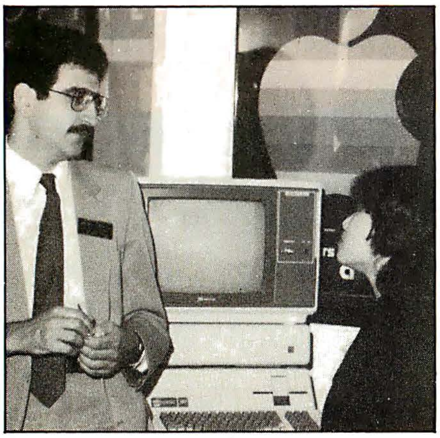
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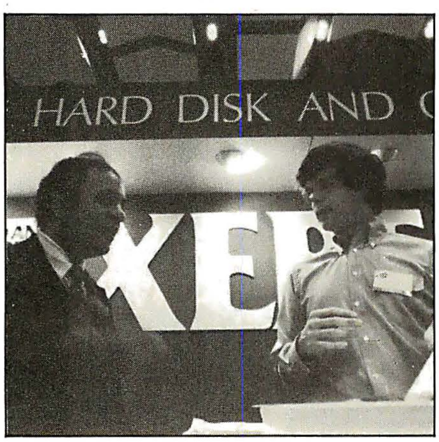
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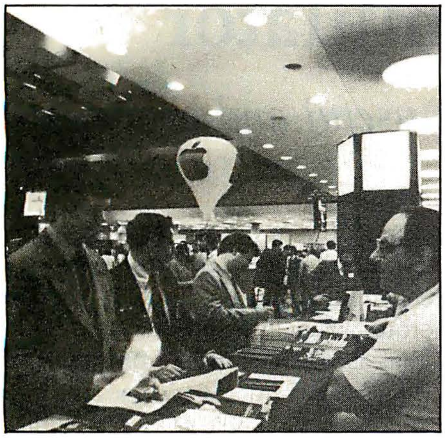
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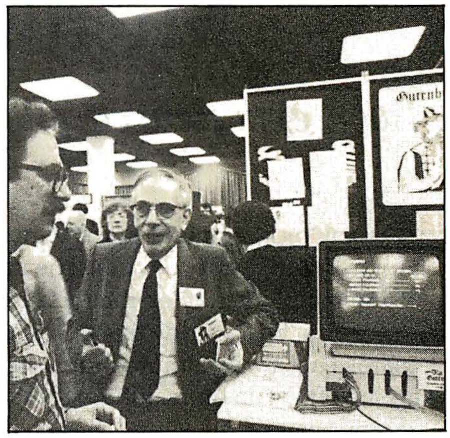
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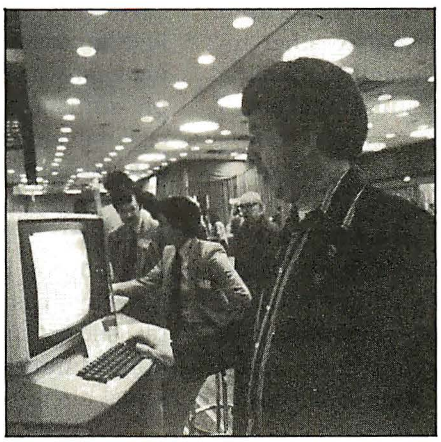
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Microsoft Flight Simulator

Even experienced pilots will find this program useful and challenging

by Stan Miastkowski

As any programmer knows, simulations are one of the toughest programs to write. The seemingly endless list of interacting variables that comprise events that happen in the "real world" makes for a programmer's nightmare. That's why simulations used by serious researchers are often run on mainframe computers or even supercomputers like the Cray-1. Their incredible speeds and megamemories make them capable of processing the numerous variables and the endless streams of data used in such advanced fields as weapons and weather research—not to mention that the government is often the only entity capable of laying down the substantial bucks required for systems like these.

Despite the inherent roadblocks, programmers of minicomputers and microcomputers are forging new ground in simulations. Not all of the work is being done in esoteric scientific fields. In fact, microcomputer-based simulations are becoming increasingly common in the entertainment arena. Some of the most advanced work has been done by Atari's Chris Crawford (see "Chris Crawford: Artist as Game Designer," June 1982 *Popular Computing*, page 55), who's responsible for such groundbreaking games as Eastern Front.

Flight simulators for microcomputers have been around almost since the beginning. Most have been rather crude, relying on slowly updated primitive graphics or an instrument panel only. Although fun for the nonpilot, they haven't had enough features for an experienced pilot to find them useful or challenging. The Microsoft Flight Simulator is a refreshing exception, a fast-moving, realistic package that makes you consider all the variables and make the fast decisions that a pilot must make.

Flight

Although highly experienced pilots with tens of thousands of hours "behind the stick" often tell you that flying becomes boring, don't be deceived. Flying an airplane, be it a Cessna trainer or a Boeing 747, is an exhilarating experience that requires complete concentration on the numerous visual and sensory cues (sound, movement, etc.) that assail the senses from the instruments, radios, and outside world. It truly uses the brain's ability to parallel-process large amounts of data. But how do you develop a flight simulator?

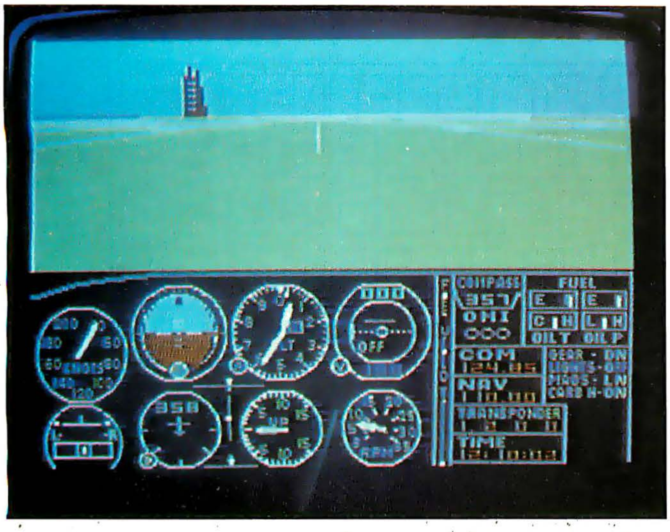
The complete-environment simulators used by the airlines for training pilots are one extreme. Sometimes costing nearly as much as a real airplane, these closed-cockpit simulators are mounted on hydraulic legs to simulate movement and utilize high-resolution computer-generated graphics projected onto a large screen that sits in front of the pilots. The mind-boggling array of instruments in a modern jet cockpit are all there, and the whole thing is usually controlled by a superminicomputer such as a Digital Equipment Corporation VAX. So realistic are these simulators that the FAA (Federal Aviation Administration) recognizes them as equal to flying a real aircraft for part of a pilot's training program.

Obviously, more than a couple of compromises are in order for a flight simulator that uses a personal computer. Movement must be simulated on the screen only, and computer-generated representations of the instruments also must be on the screen. In addition, the programmer must be well aware of the limitations of the processor, memory, and graphics capability of the computer used.

The Microsoft Simulator

The Microsoft Flight Simulator runs on the IBM Personal Computer (along with the Corona [with graphics board], the Chameleon, the Compaq, and several other PC clones), a logical choice because of its 16-bit processor and high-resolution graphics. It comes on a single 5¼-inch floppy disk, so it can be used on a single-drive

(1a)



(1b)



Photo 1: *The view forward while waiting for takeoff clearance is shown in 1a. Note the instrument status. Photo 1b shows the situation just after lift-off, banking to the right. Instrument indications correspond to control settings and aircraft speed and attitude.*

system. The disk's built-in copy-protection scheme allows you to make a single backup copy, a wise thing to do because the simulator quickly can become habit forming and the disk will get heavy use. It requires only the minimum memory (64K bytes), although you'll need the color/graphics card.

A word about the video display: although when you boot the disk the flight simulator asks you which type of display you're using (color TV/composite monitor, black-and-white TV/monitor, or RGB monitor), the realism of the simulator depends highly on the use of color. It will work in full color only with a color TV or composite monitor; an RGB (red-green-blue) display will display black and white. Although a color composite monitor is by far preferred, I found a color TV adequate (though a bit tiring on the eyes). You *need* color for one good reason: a pilot uses color to sort out the visual cues, both from the instruments and the view out the window. The one exception is night flying (available in the simulator) where, in real conditions, instruments are red-lighted to ensure that night vision isn't affected. In the simulator's night-flying mode, the instruments remain the same color they are in the "daylight," not exactly realistic but still quite usable.

I strongly recommend staying away from this package if you don't have access to a color video display. Although you can still use it, it will soon become frustrating. Lack of color takes away a large degree of its realism. Besides, if you're color blind, the real world denies you the medical certificate needed to fly as pilot in command.

The simulator comes with a complete 93-page manual that includes several charts used for both VFR (visual flight rules) and IFR (instrument flight rules) flying. These are partial versions of actual government maps, the ones used by pilots during real flights. The manual, though a complete step-by-step run-through of the simulator, is a bit difficult to use as a reference guide. I found I had to make up my own place markers for areas I'd be referencing often.

When you first boot the disk and select the video-display type, you're given the option of entering demo mode or regular flight mode. The demo mode is a good place to start, taking you through a short flight and letting you get a feel for the features.

The video display is divided horizontally into two parts (see photo 1). The top part is the view out the "windshield" of the airplane. This high-resolution view is upgraded about three times a second, resulting in a sometimes-uncanny degree of realism. The resolution is excellent, and objects on the ground are clearly discernible for what they are, rather than just a hazy intersection of jagged lines. However, don't expect to see intimate details of the cities and towns you're "flying" over. Because of obvious memory limitations, three-dimensional objects are outlines, without details filled in.

The lower part of the display contains the instrument cluster, including the standard airspeed indicator, artificial horizon, altimeter, turn coordinator, heading indicator, and rate-of-climb indicator found in every airplane. In addition, you'll find an Omni-Bearing Indicator with glide slope (for landings during instrument conditions), a clock, magnetic compass, and various annunciator lights that monitor lights, landing gear, carburetor heat, and outer/middle/inner markers (also used for instrument landings). There's also a full complement of instruments that monitor the engine, including a tachometer, oil temperature and pressure gauges, and, most important, dual fuel gauges for left and right tanks. A single NAV/COM (navigation/communication) radio is provided, as is a radar transponder that sends a coded signal every time a pulse from tracking radar hits the airplane.

All in all, the plane is very well outfitted. About the only things missing are an ADF (automatic direction

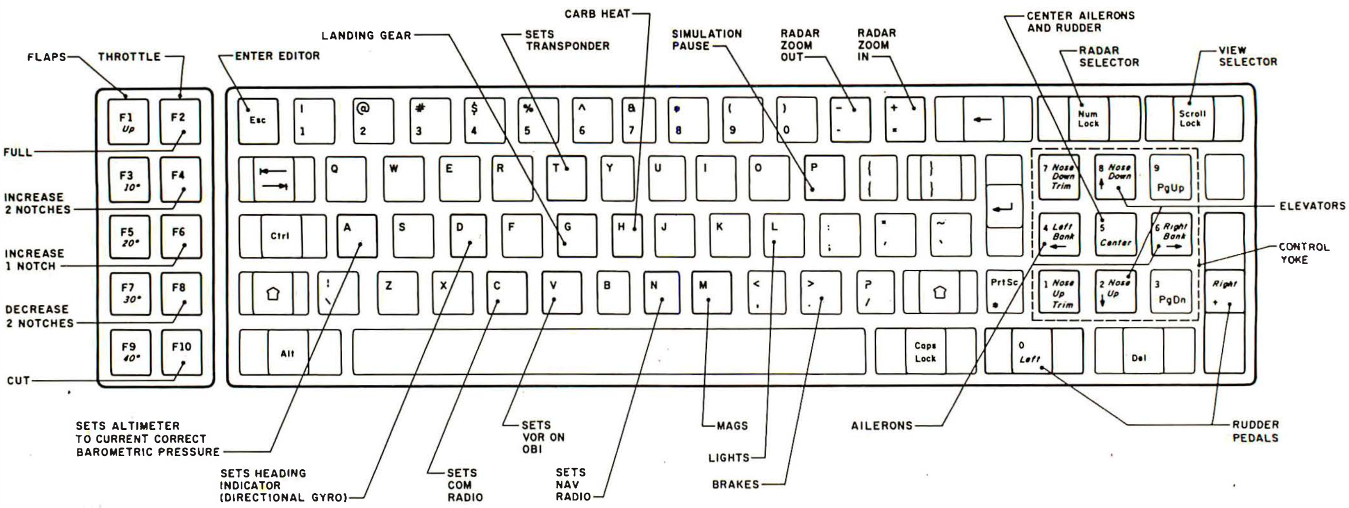


Figure 1: *Aircraft controls for the flight simulator. The British Ace mode adds a declare-war key (W) along with bomb-drop (X) and machine-gun burst (space bar).*

finder) and a second (or even third) NAV/COM radio. The many frequency changes needed during instrument flight and during a departure from or approach to a moderately busy airport can be maddening with only a single radio.

The Microsoft Flight Simulator was designed by its author, Bruce Artwick of Sublogic Corporation, to simulate a Cessna 182. This single-engine aircraft—called the Skylane—delivers relatively high performance. Because an airplane like the Skylane has enough power and controls to get you into trouble, it's not normally used for student training. The simulator acts surprisingly close to the Skylane, the major difference being that the simulator can climb a bit faster than the "real thing." Another difference between the simulator and the Skylane is that the simulator has a retractable landing gear instead of the Skylane's fixed landing gear.

Flight Controls

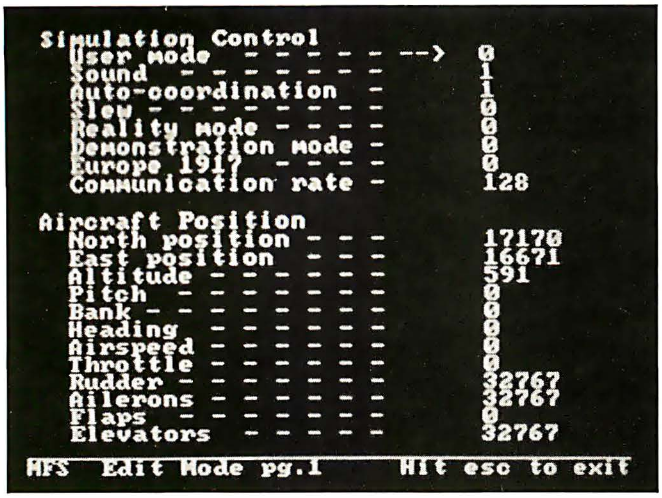
In an actual airplane, you control it using four major controls:

1. *Yoke.* This is the "steering wheel" of the airplane. Turning it right or left controls the *ailerons* on the tips of the wings and banks the aircraft right or left. Pushing it in and pulling it out controls the *elevator*, the large horizontal wing on the back of the airplane. Pushing it forward tilts the nose down; pulling it backward tilts the nose up.
2. *Rudder.* This is the vertical wing on the back of the airplane, which is controlled by two pedals on the floor. It controls the left to right axis of the airplane. Maneuvers such as turns actually cause the airplane to *slip* sideways unless the turn is *coordinated* with the rudder. On the ground, most airplanes have the front-wheel steering connected to the rudder pedals.
3. *Throttle.* The amount of power in an airplane controls its rate of climb and descent as well as its airspeed. In fact, proper use of the throttle is one of the most difficult aspects of flight to learn. Landing an airplane properly is a fine art of controlling descent using power and the yoke so that the airplane *stalls* (stops flying) several inches above the runway.
4. *Trim.* Depending on the power and airspeed, as well as conditions such as passenger and equipment load and quantity and location of fuel, the force needed on the yoke to make the airplane perform a maneuver can vary greatly. The trim is a fine adjustment that equalizes the forces on the airplane.

Obviously, there's no yoke, throttle, trim lever, or rudder pedals on the IBM PC. Therefore, these variables are controlled by the keyboard (see figure 1). The primary controls are clustered on the numeric keypad located on the right side of the IBM keyboard. The primary yoke controls are in a standard cross configuration, with 2 (↓) and 8 (↑) controlling the nose attitude (elevator) and 4 (←) and 6 (→) controlling left and right banking (ailerons). The 0 (left) and + (right) keys are your "rudder pedals" and throttle position is controlled by the even-numbered F2 through F10 function keys on the left side of the keyboard. In all cases, pressing key 5 on the keypad centers the yoke. Because you don't have that "seat of the pants" feel, indicators on the panel show you the position of your controls. You do, of course, also get visual cues, such as when the ground is rushing up on you and your airspeed is increasing dramatically. The odd-numbered function keys (F1 through F9) control the flaps, which are used to increase lift, primarily during a descent to the runway, when you're flying comparatively slowly.

Other keys on the main keyboard control functions such as turning the lights or carburetor heat on and off and setting the frequency on the radios. The most important one is P, for pause. It lets you take a break during a difficult instrument approach—something you obviously can't do in real life.

(2a)



(2b)

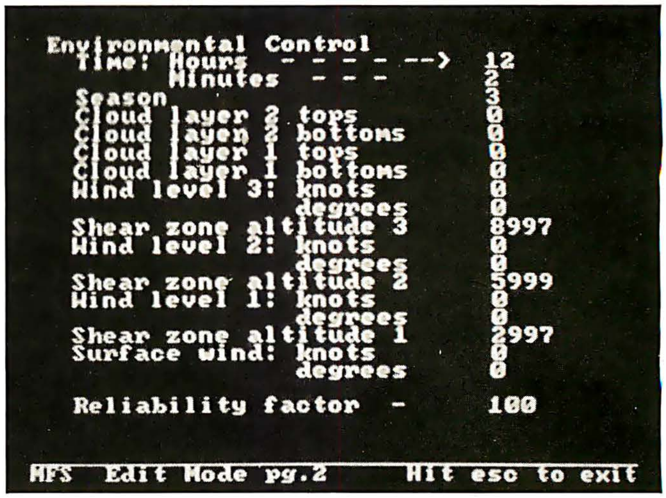


Photo 2: *Pages 1 (2a) and 2 (2b) of Editor screens. As you can see, many variables can be changed to vary flight conditions.*

The Editor

One of the keys to any good simulator is to make sure it doesn't repeat itself. This is where the Microsoft Flight Simulator shines. The Editor (see photo 2) lets you set up an almost infinite variety of flight conditions, including the time of season, time of day, cloud layers, wind, turbulence, and, most important, the location. The simulator is a real-time program, and you can actually fly between Seattle and Los Angeles, although it will take several hours. The simulator has geographic detail and airport information for four areas: Seattle, Los Angeles, Chicago, and New York/Boston. Each area comprises about 10,000 square miles. For convenience sake, you'll probably want to limit your flights to airports within these areas, which include plenty of variety. You tell the simulator the latitude and longitude of where you want to start (normally on the ground at the airport). You can also start off in the middle of a flight if you wish.

At a Glance

Name
Microsoft Flight Simulator

Use
Simulates VFR/IFR flight in a Cessna 182 single-engine aircraft

Manufacturer
Microsoft Corporation
10700 Northup Way
Bellevue, WA 98004

Price
$50

Features
High-resolution real-time graphics display, full VFR/IFR instrumentation, 10 preset flight modes, 20 customizable flight modes, parameters can be stored in RAM to restore position, British Ace World War I game, pause key, and ability to make single backup

Format
5¼-inch floppy disk for IBM Personal Computer; requires 64K bytes of RAM, a single floppy-disk drive, and a color-graphics board

Documentation
93-page tutorial manual

Audience
Student pilots, experienced pilots, prospective pilots, and anyone interested in a full-featured simulation of what flying an airplane is like

In addition to the 10 preset modes, you can set up and store up to 20 more modes.

Ten preset flight modes are included on the disk, ranging from easy flight to advanced instrument conditions in bad weather. One of the modes is British Ace (see photo 3), where you're a World War I ace flying against Germany. When you get sick of normal flying, you can enter this mode and have machine guns and bombs at your disposal over the terrain of France and Germany. It's a pleasant diversion that still requires a good deal of flying skill, and you won't succeed if you haven't spent some time using the easy flight mode.

In addition to the 10 preset modes, you can set up and store up to 20 more modes. This gives you a large variety of flights that you can make.

A Sample Flight

To give you an idea of how the simulator works, let's take a quick flight. When you choose the easy flight mode (which is automatically entered from the first menu), you're lined up on the active runway of Meigs Field, a small airport located next to Lake Michigan near Chicago. Because it's an uncontrolled airport (no control tower), you're all set to take off. You can, if you wish, "taxi" around the airfield using a unique "radar" feature (see photo 4) that you don't find in a real airplane. Pressing Num Lock gives you a view of the airport from above,



Photo 3: *The view forward in the British Ace mode selected by the Europe 1917 option in photo 2b. Note the addition of a sighting device in the windshield and an armament indicator and attack radar at the lower right.*

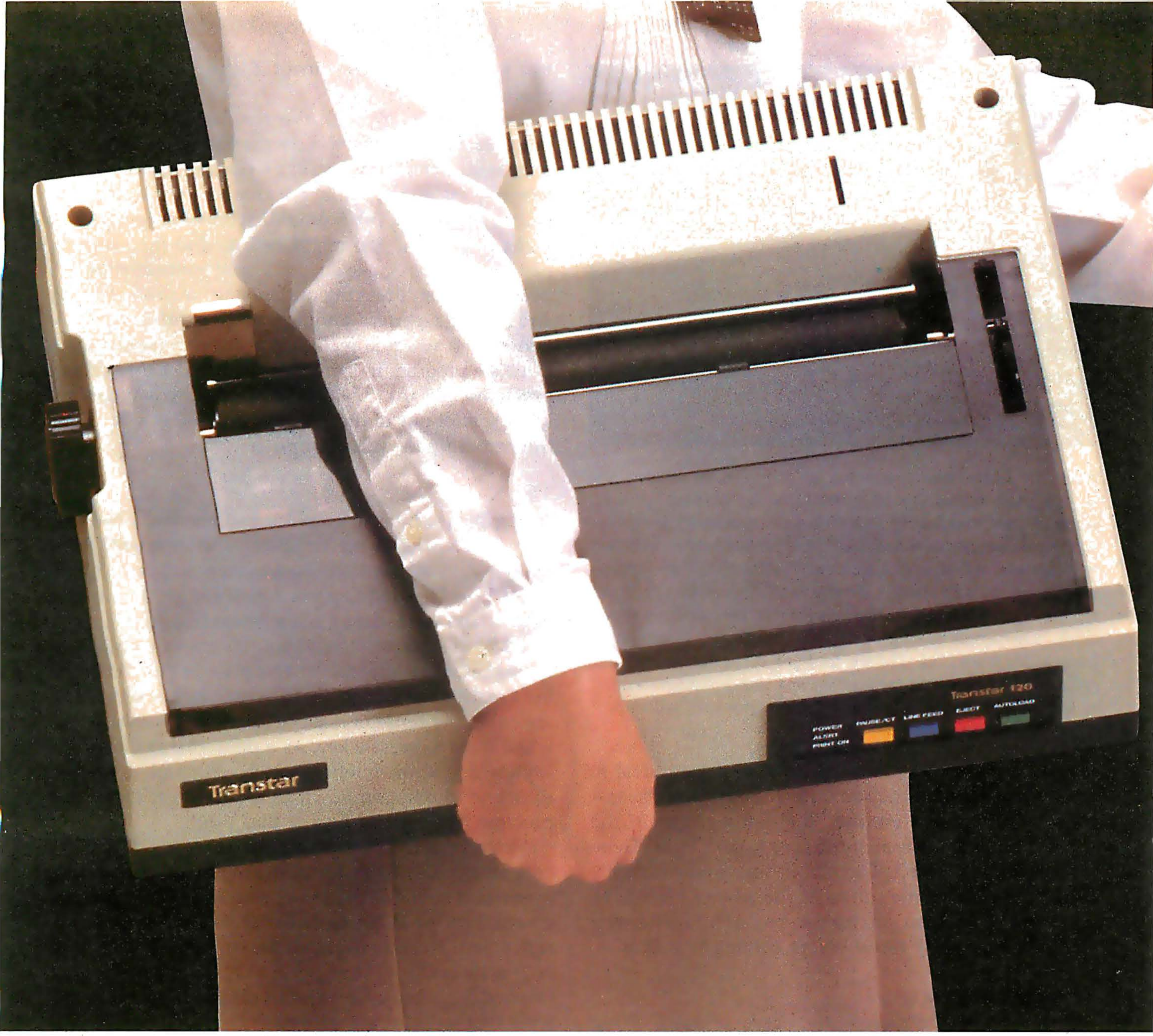
with your aircraft in the middle. You can taxi around the airfield using your throttle, and zoom the view in or out using the + or − keys. If only real airplanes had this. The taxiways at large airports are confusing masses of intersections and branches going off in many directions. They can be murder if you're not familiar with the airport. I well remember flying a small Piper aircraft into Logan Airport in Boston and being told by ground control to taxi "using the inner delta." Absolute gibberish!

Once you're lined up on the runway (see photo 1a), you can hear the engine sounds coming from the speaker. (It can be turned off.) After a standard pretakeoff check, you apply full throttle by hitting the F2 key. The engines rev up, and you steer to keep yourself in the middle of the runway using the rudder keys. When you reach 55 knots as shown on your airspeed indicator, you raise the nose by pressing key 2 about six times. You're off (see photo 1b). In addition to the airport and the lake, the John Hancock Tower is visible. For this VFR flight, the tower is an excellent reference.

The adjustments that you must make on the flight simulator are very much what would be done in a real aircraft. After the gear is up, you gain a bit of airspeed and can slightly reduce power to get the best rate of climb. The easy flight mode is a perfect way to get used to the feel of your computerized airplane. Turns are automatically coordinated, which means you don't have to worry about the rudder controls whenever you bank the aircraft.

Landing, as in a real airplane, is the toughest part. The best thing to do before even attempting it is to fly out over the lake and try turns, ascents, descents, and flying at a constant altitude until you're absolutely sure you're comfortable with your aircraft. Experienced pilots will spend a great deal of time looking at their instruments, the best cues for what's happening. Unless you're particularly talented (or lucky), you'll probably crash more than a couple of times. As in a real aircraft, there's a strong tendency to overcorrect on your controls, making the situation worse. With all the graphics and sound, you might expect a realistic crash. Sadly, that's not the case. If you crash, all you see is "CRASH!" on the screen. If you spin into the lake, you'll see "SPLASH!" Somehow, I expected more.

You have to face the fact that unless you're specially gifted you're going to botch up landings. Although I've done hundreds of real landings, I found getting used to using the keyboard a big hurdle to overcome. As pre-



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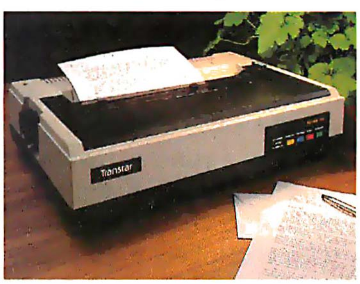
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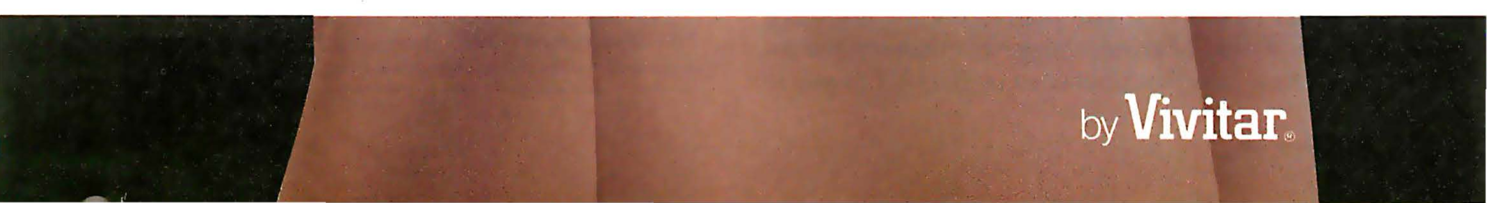
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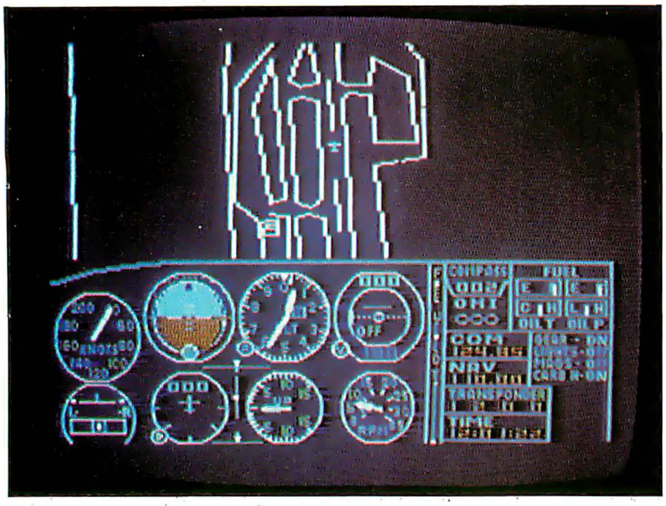


Photo 4: *"Radar" view of your aircraft at rest on the runway. Left to right, the top four round instruments are airspeed, attitude, altimeter, and Omni-Bearing with glide slope (navigation); the bottom four round instruments include a turn coordinator, heading indicator, vertical-speed indicator, and tachometer. Also shown are control-position indicators for ailerons, elevator (and trim), rudder, flaps, and throttle. Beneath the compass (top right) are outer/middle/inner marker lights, communication and navigation radios, an identification transponder, and a clock. The top, far right, of the instrument panel holds fuel and engine oil temperature and pressure gauges as well as landing-gear, lights, magneto, and carburetor-heat indicators.*

viously mentioned, a landing involves a great deal to reach the ground at the same time the runway starts—without hitting the ground. It's damn tough in the simulator and took me about 15 tries to get it right. There was a satisfying feeling of accomplishment when I finally made it and heard the squeal of the wheels hitting the pavement. Even then you have to be careful—otherwise you'll bounce a few times before coming to a stop.

Advanced Flying

Once you've conquered the rigors of basic flying (which might take weeks of concentrated effort for beginners), you can graduate to more involved flights, such as those at night or from airports with control towers. Messages from the tower appear as text that marches across the top of your screen. Just as in a real airport, you'll receive clearance, contact ground control, taxi to the active runway, contact the tower (which will give takeoff clearance), and take off. All along the way you'll be told to change frequencies and will stay in contact with controllers until you're out of the airport area. It's incredibly realistic.

The pinnacle of the pilot's art is flying by instruments. Getting an instrument rating is a long and involved process that requires many hours of concentrated ground and flight instruction. Although Microsoft's manual tells you all you need to know about how to operate the instruments, understanding *how* to fly by instruments is well beyond its scope. If you plan to do any extensive instrument flying, Microsoft suggests obtaining the *Instrument Flying Handbook* published by the FAA. If you're not familiar with instrument flight, it's an absolute essential.

Instrument flying with the simulator is, if possible, even more fun than VFR. Like the real thing, it requires intense concentration. You can fly complete trips in IFR, receiving instructions from the ground and tracking your course using VOR (VHF omnidirectional range) stations along your path. You might be asked to fly a holding pattern and then make an instrument approach through heavy overcast. Breaking out lined up with the runway and making a perfect landing is truly an exhilarating experience. If you're a real glutton for punishment, you can even program in some heavy turbulence or aircraft problems that can be surprising. Making a successful landing after one of these flights may tempt you to kiss the carpet under your computer.

The Negatives

Despite its fantastic graphics and realism, I had one large problem with the simulator, the keyboard. After many hours of use, I still had to stop and think about which keys I needed to press in order to get the airplane to do what I wanted it to. Sometimes the delay was fatal. Unlike a real aircraft simulator, it's never possible for more than a few seconds to actually feel like you're flying a real aircraft. Airplanes use controls, not keyboards; and whatever sense of reality existed quickly evaporated when I had to press a key. As a pilot, that reality of the keyboard was an intense bother, although I suspect someone who's never flown an airplane won't have that problem to the same degree that I did.

With all the features programmed in, it's difficult to criticize the simulator for a few minor inconsistencies over a real aircraft. The major one, which amused me greatly, was the ability to do barrel rolls and even fly upside down. The actual aircraft the simulator is patterned after is incapable of doing that. Airplanes designed for inverted flight must have special oil and carburetion systems that work in any attitude.

Conclusions

The Microsoft Flight Simulator is a tour de force of the programmer's art. It acts like a real airplane, and the numerous variables that must be kept track of in actual flight are required here as well. It can be an excellent introduction to how an aircraft actually operates for a budding or student pilot and can even help instrument pilots or those going for an instrument rating sharpen their skills. It is, however, no substitute for professional FAA-approved flight instruction and is not recognized by flight schools or the FAA, so don't expect credit. The major block to its being rated excellent is that you *must* use a keyboard. I suspect that prospective pilots who use the flight simulator first may have some problems in converting to a real control yoke and rudder pedals. ■

Stan Miastkowski (POB 445, Peterborough, NH 03458) is a licensed pilot and currently is the computer columnist for Esquire *magazine.*

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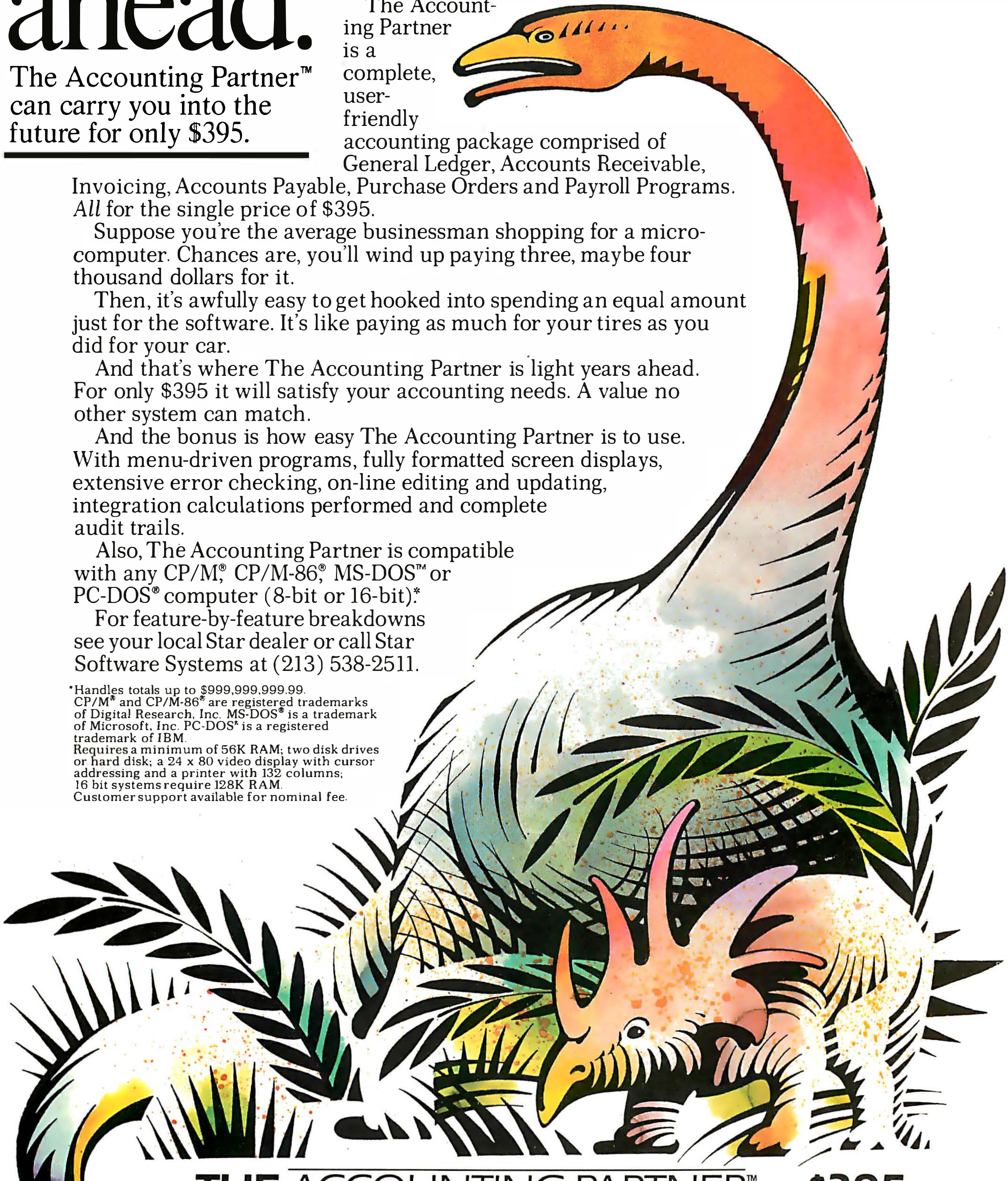
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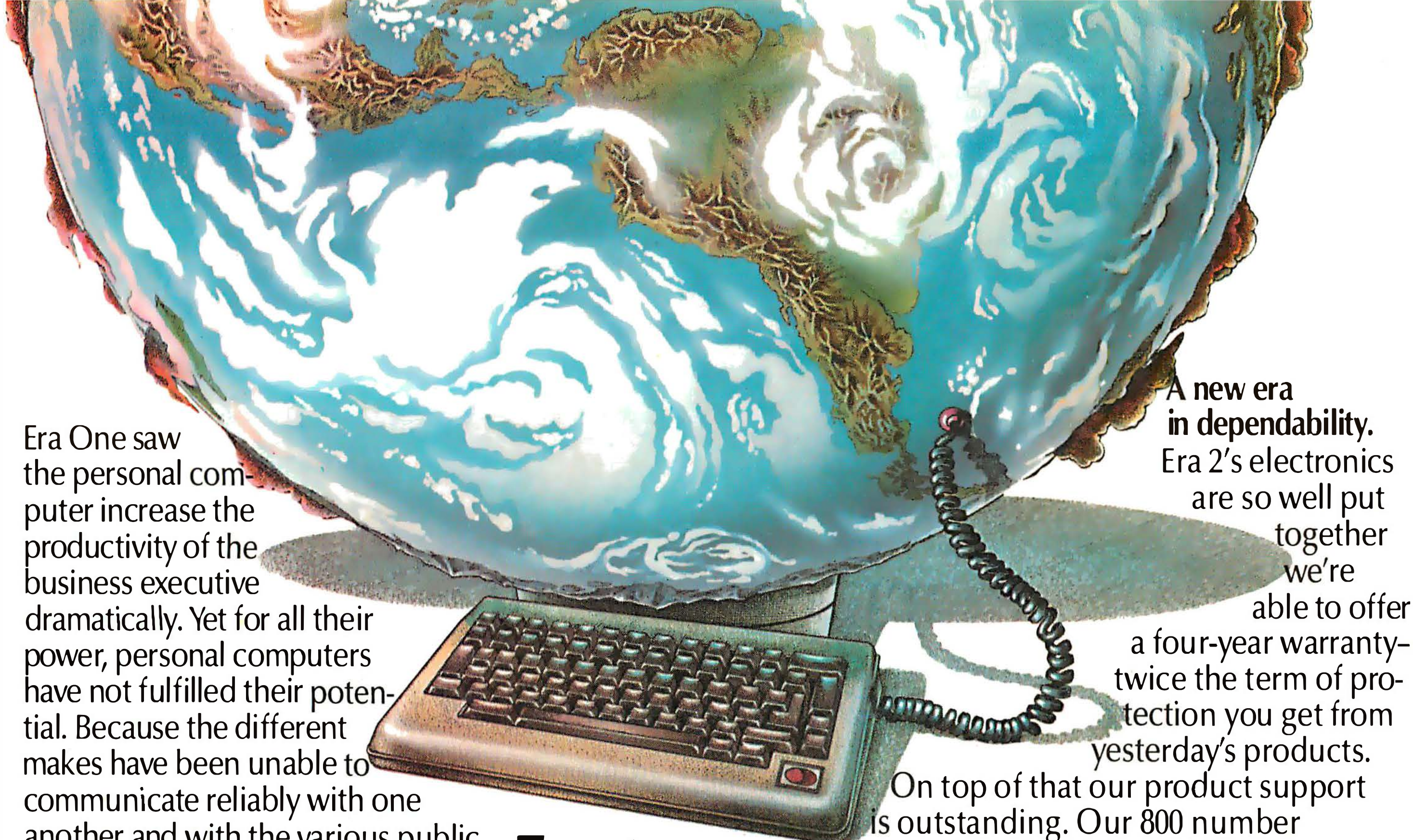
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The Eagle PC

A clone with a few improvements and a few mistakes

by Tom Wadlow

The *Eagle PC Reference Guide* describes the Eagle PC as "a compact, modular personal or business computer system for the serious user with an eye to his budget." The Eagle is all those things, but it does have its shortcomings.

The bottom-of-the-line Eagle PC is the Eagle PC-E, which costs $1995 for 64K bytes of RAM (random-access read/write memory), one 320K-byte floppy-disk drive, a keyboard, a parallel port; and two serial ports. It comes with no display board, monitor, or software. For $3495, you can get the Eagle PC-2, which comes with 128K bytes of RAM, two 320K-byte floppy-disk drives, a monochrome monitor, MS-DOS and CP/M-86, Eaglewriter, and Eaglecalc. Photo 1 shows the Eagle PC-2.

Hardware

Physically, the Eagle PC resembles the IBM PC. A pleasant feature for those with limited desk space is the little alcove underneath the chassis. You can slip the keyboard into this alcove when the system is not in use. The cavity, shown in photo 2, extends to the rear of the machine on the right side so that the keyboard cable can be routed through it. This is far superior to IBM's layout, in which the keyboard cable must come around the side of the machine, where it can get in the way. Unfortunately, the Eagle's cord enters the keyboard enclosure at an angle that guarantees the keyboard will not slide easily into the alcove. You can get around this by picking the keyboard up as you place it in the cavity, but a quick, one-handed push would have been nicer.

The Eagle has carried over one of my pet gripes from the IBM. I prefer to place my monitor beside the computer rather than on top of it. Both IBM and Eagle put their video connectors and power connectors on opposite sides of the rear of the chassis, so no matter which side you put the monitor on, one of the cables will be too short. An extra six inches of cable would eliminate this problem.

The Eagle's construction leaves something to be desired if you intend to do simple maintenance on it. There are no less than 17 small screws of three similar (but not identical) sizes that you must remove to get at the inside of the unit. As a result, changing one of the power-supply fuses (two are outside, one inside) or adding a new set of memory chips involves removing and replacing 17 soft-metal Phillips-head screws. Do it with extreme care and you won't have a problem. But it doesn't take much to strip the slots for the screwdriver and wind up with a jammed screw.

The Eagle does not perform a lengthy memory test on power-up, as the IBM PC does, so the machine will boot almost instantly when turned on. It can also be warm-started in the same manner as the IBM PC, by typing Ctrl-Alt-Del as one keystroke. And like the IBM, the Eagle cannot perform this vital function (short of turning the power off) when a program bug trashes the software that listens for a Ctrl-Alt-Del.

In my opinion, the hierarchy of personal computer features should be as follows: display, keyboard, mass storage, and anything else. The quality of the display should take precedence in both design time and effort over the keyboard, and the keyboard over the mass storage, and so on. Engineering involves compromises between goals and costs, and while a properly designed computer will still have compromises, they should be deep enough inside the machine to escape notice. Compromising a display or keyboard is asking for trouble.

By this measure, the Eagle isn't quite up to what I would like to see in a personal computer. The optional Eagle display, when no motion is taking place, is a very

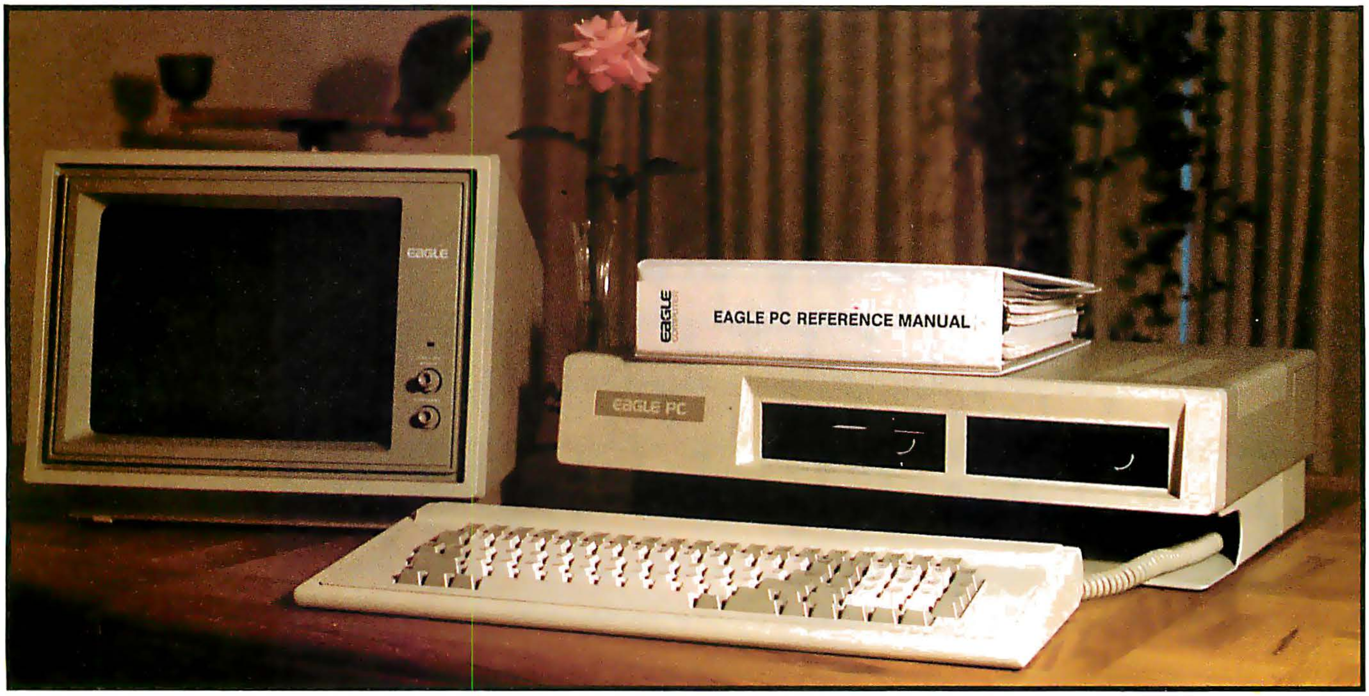


Photo 1: *The Eagle PC.*

close copy of the IBM monochrome display. Motion, however, is a different story entirely. The Eagle monochrome display scrolls in a visible ripple that is quite unpleasant to watch. Combining this with the long-persistence phosphor on the monitor makes the Eagle display annoying for any serious text editing. An IBM monochrome display board does work quite well, however, in place of the Eagle display. It produces both attractive text and acceptable speed. I couldn't tell if bad interactions take place between the two printer ports when an IBM display is used. Since the expansion bus is also IBM PC compatible, most of the display boards on the market should work with the Eagle. As with all such mix-and-match components, you should check with the manufacturers to ensure compatibility.

My biggest complaint about the Eagle concerns the keyboard (see photo 3). The keyboard is the means by which you communicate with your computer. The better you can do that, the better you can use your computer. I am a touch-typist and have used dozens of keyboards, both professionally and personally, over several years. These days, I move quite easily between my home IBM keyboard (with its accursed Shift and Backspace keys) and a Lisp Machine keyboard at work (which has seven different kinds of Shift keys, any combination of which can be, and often is, used with a single character). As you can see, I am used to dealing with a variety of often quite peculiar keyboards.

The Eagle keyboard certainly qualifies as peculiar. While the alphanumeric keys are laid out more traditionally than on the IBM keyboard, they are not as widely spaced. My left hand always found the proper Home keys, but my right hand invariably went one key too far to the right. The Eagle keys have a mushy feel, with very little tactile feedback. This is fine if you just want to hit a key or two, but with extensive typing or word processing, it becomes quite bothersome.

There are some serious errors in the layout of the other keys. My particular favorite is the way the cursor-control keys are laid out. The IBM PC places cursor control on the 2-4-6-8 keys of its numeric keypad. This layout is satisfactory, unless you want to enter numbers and move the cursor at the same time, which is not uncommon. Eagle chose to remove the cursor-control keys from the numeric pad and place them between the Enter key and the numbers. So there, in a vertical column, you have Up, Right, and Down. The Backspace key does double duty as Left, but you have to type Shift-Backspace to get the proper Left code. This layout is not very intuitive, not to mention being somewhat uncomfortable, and you

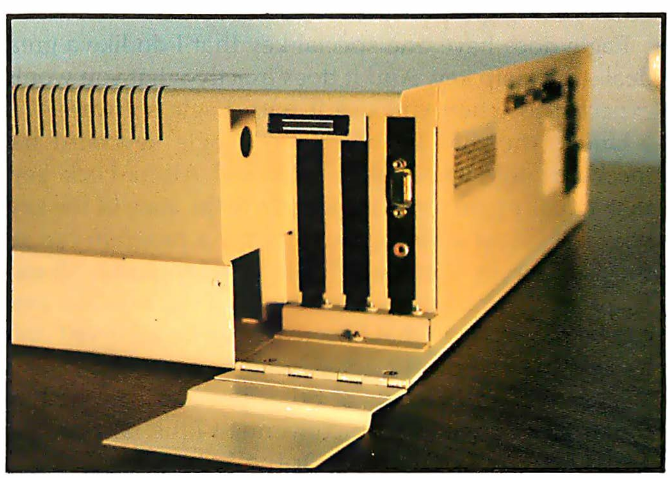


Photo 2: *The expansion-card connector cavity. The keyboard connector is to the left of the card connectors.The dark rectangle at the top is the magnetic catch. To get at the expansion slots, you can remove the piece of metal to which the cavity door is hinged.*



Photo 3: *The Eagle's keyboard.*

spend a lot of time rubbing out characters every time you want to move left.

A little experimentation produced the undocumented fact that the 2-4-6-8 keys on the number pad do produce cursor-control codes when shifted. Unfortunately, neither the Shift-Lock nor the Alpha-Lock keys affect the number keys at all, so you must always hold down a Shift key to use this feature.

Many of the function keys are labeled with functions for one or more of the Eagle applications programs. For example, hitting the function key labeled Files in Eaglecalc displays a directory of the current disk. While I have nothing against this per se, it seems to me that a general-purpose keyboard and a nice set of cardboard overlays would save us all the trouble of explaining to a novice why the Files key doesn't work with dBASE II or some other non-Eagle product.

Eagle does have one special key that I do like a great deal—the Help key. And it does exactly what you would expect it to when you use it with Eagle software.

Unlike the IBM keyboard, the Eagle keyboard has mechanically locked Shift-Lock and Alpha-Lock keys that actually give some indication of the state of the keyboard. It is just a hint, though, since a program can set these locks in software. Thus, under some all-too-frequent circumstances, the actions of the two lock keys can be reversed, so that lowercase can be achieved only by keeping the Shift-Lock down.

The keyboard has lots of other peculiarities, such as the numeric keypad with convenient Plus, Minus, and Times keys, but no Divide. Or the Enhance key, which is as big as the Enter key and takes up a space that would be a pretty good location for a correctly configured set of cursor-control keys. Enhance is used only in Eaglewriter, and I really had to dig in the manual to find out where. But the major peculiarity of this keyboard is that it exists at all. Several companies are making good money selling properly designed keyboards for the IBM PC. If Eagle had simply chosen one of those keyboards, it would be in a very enviable position compared to the IBM PC. Perhaps the "not invented here" syndrome isn't limited to IBM. As Eagle's keyboard exists today, the only people that will benefit by its presence are the companies that sell Eagle-compatible replacement keyboards.

The Eagle can support two double-sided double-density disk drives; the second drive is optional. They are half-height Teac drives, and the design of the enclosure precludes any possibility of converting to more than two half-height drives (as you can do with the IBM PC). I had no problem running the disks with MS-DOS 1.1 (giving each a formatted capacity of 320K bytes) or with MS-DOS 2.0 (capacity 360K bytes). Disk access is not as fast as the IBM PC; in fact, formatting a single floppy disk on the Eagle takes several times longer than formatting on the IBM. It seems to be a problem with either the disk controller or the low-level Eagle software, since both MS-DOS and CP/M-86 maintain this snail's pace.

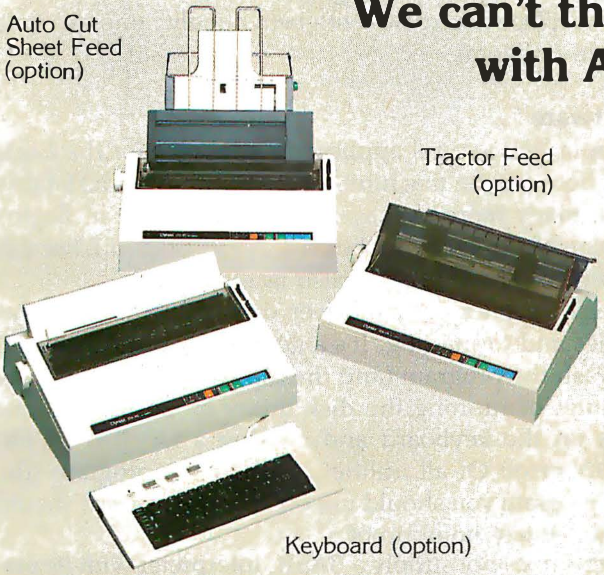
The Eagle has a three-slot expansion bus for the addition of special boards. One of these slots is used for the display board and one is used for the disk controller, so, in effect, you have only one slot to play with. Luckily, the major uses of the expansion slots are already taken into account on the motherboard. For instance, the Eagle has enough memory-chip sockets to handle up to 512K bytes of RAM. Eagle has also done what IBM should have: included one parallel and two serial ports on the motherboard. So most typical uses for a PC can be met with an Eagle and one board.

Access to the expansion bus is through a plate screwed

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At a Glance

Name
Eagle PC

Use
IBM PC-compatible desktop computer

Manufacturer
Eagle Computer Inc.
983 University Ave.
Los Gatos, CA 95030
(408) 395-5005

Components

All models: The system unit is 20.5 inches wide by 5.75 inches high by 13 inches deep. The keyboard is 19 inches wide by 1.75 inches high by 8.75 inches deep. The entire system weighs about 40 pounds. All feature a 4.77-MHz 8088 microprocessor, a 105-key separate keyboard with 24 user-definable keys, RAM expandable to 512K bytes on the main board, two built-in RS-232C ports, and one parallel port. Also, they have three expansion slots—one for the disk controller, one for the display (except PC-E), and one for additional devices.

Eagle PC-E: 64K bytes of RAM and one 320K-byte floppy-disk drive

Eagle PC-1: 128K bytes of RAM, one 320K-byte floppy-disk drive, and a 12-inch, 720- by 320-pixel monochrome monitor

Eagle PC-2: 128K bytes of RAM, two 320K-byte floppy-disk drives, and a 12-inch, 720- by 320-pixel monochrome monitor

Eagle PC-XL: 128K bytes of RAM, one 320K-byte floppy-disk drive, and a 10-megabyte hard-disk drive

Software
MS-DOS, CP/M-86, Eaglewriter, and Eaglecalc are included with the Eagle PC-1 and PC-2. This software costs $810 separately.

Options

Hardware

64K-byte RAM add-on kit	$135
8087 coprocessor	$495
320K-byte floppy-disk drive	$500
10-megabyte hard disk	$2495
32-megabyte hard disk	$3995
Hard-disk interface	$125
Monochrome monitor	$329
Monochrome adapter	$295
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Software

MS-DOS	$60
CP/M-86	$60
MP/M-86	$395
GW BASIC	$245
Eaglewriter	$495
Eaglecalc	$195
Flex Menu	$50

Documentation
An Eagle PC Reference Guide for novice users, but no technical documentation. Eagle-supplied programs contain a great deal of on-line documentation.

Price

Eagle PC-E	$1995
Eagle PC-1	$2995
Eagle PC-2	$3495
Eagle PC-XL	$4495

Comments
Poor keyboard, marginal display. Seems to run most IBM PC software.

to the bottom of the Eagle chassis. Thus all the boards are "upside down" compared to their orientation on an IBM PC. Even so, I found it much easier to swap boards on the Eagle than on the IBM PC. The light weight of the system unit made it very easy to disconnect the cables, flip the unit over, and pop the boards out. The connectors on the side of the board stick out into a small cavity, actually inside the body of the Eagle. On the IBM, the connectors stick out the back. To get at the board connectors, you can open a small magnetically latched door on the side of the Eagle. The keyboard connector is in the same area.

I wonder about Eagle's decision to use a magnetic latch on a piece of equipment that is going to be in the immediate vicinity of delicate magnetic media. Surely a mechanical catch would have worked equally well and eliminated the threat to the floppy disks.

Firmware

The ROM (read-only memory) routines in the Eagle are different from the IBM PC's firmware routines. Unfortunately, Eagle does not include any documentation on the low-level differences between its machine and the IBM. Eagle claims to have several technical manuals in the works, but as of this writing none were available.

Eagle now offers Revision C of its ROM set, which is supposed to emulate the IBM PC better and increase display performance. The revision also makes the Eagle fully compatible with IBM-style keyboards and the Epson MX-80 printer. I was not able to test these new ROMs, but they are currently available from Eagle.

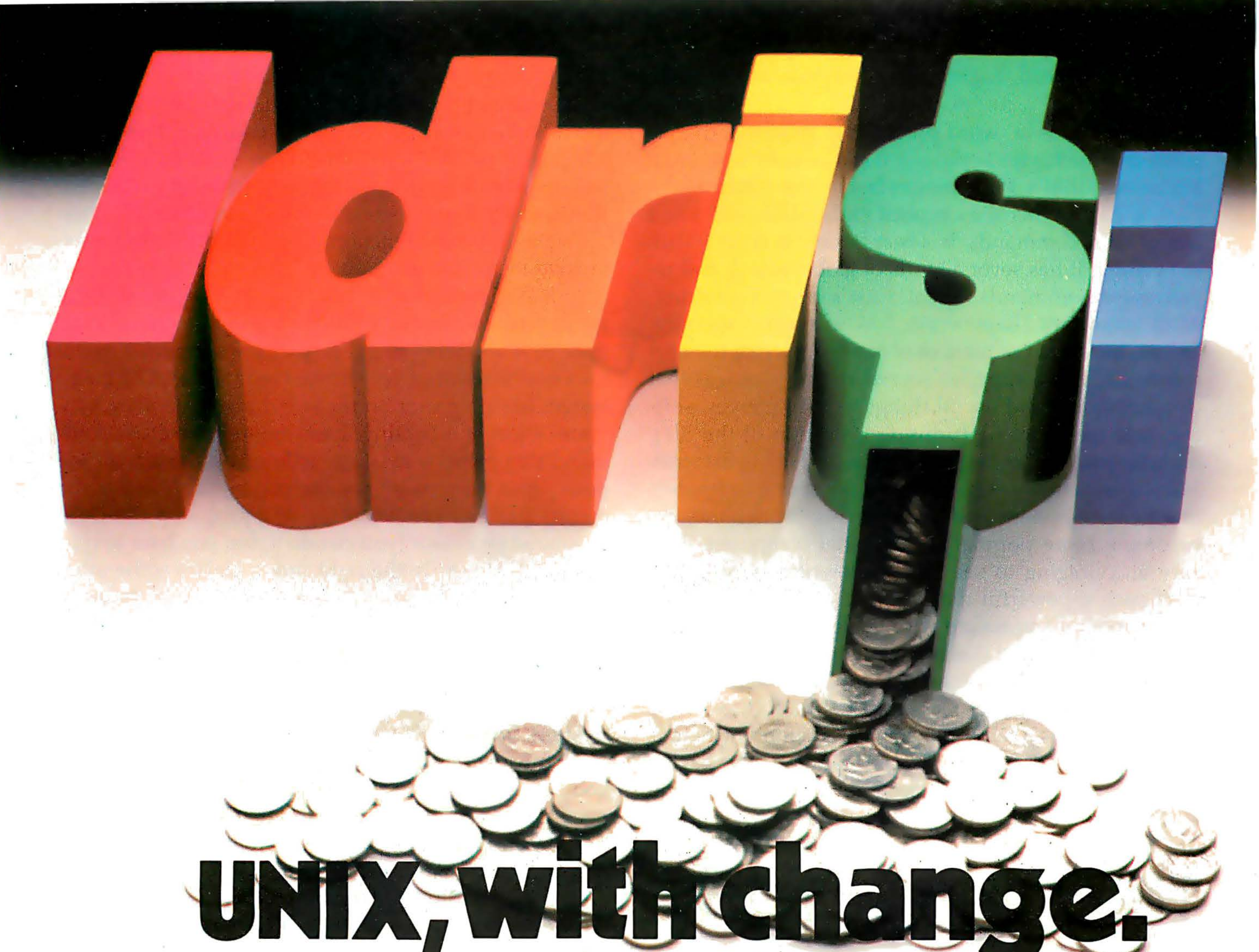
Extensive installation instructions accompany the new ROM set. You'll need to open the Eagle chassis, so be careful that you don't strip those soft screws. Performing the ROM upgrade might be an excellent opportunity to replace the screws with better quality ones to avoid future problems.

Software

Eagle sells several application packages for the Eagle PC. Because the machine seems to run MS-DOS fairly well, many more packages should run with it. Eagle's version of MS-DOS is labeled 1.25 rather than 1.1 or 2.0. A version of CP/M-86 is also available.

Eagle supplies a menu-driven disk utility that performs copies and formatting. It's a good idea, but I managed to crash the program (and the machine) in the first few minutes of running the disk utility by bumping some keys on the keyboard and causing a DIVIDE OVERFLOW error. Of all utilities, a disk-copy program (the first program you should use on any new system) should be absolutely bombproof.

Eagle does not supply a BASIC interpreter with its machine. BASIC being the quasi-standard that it is, this is



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surprising. Instead, Eagle offers GW BASIC as a separate product.

Eaglewriter is a word-processing program that is tailored to the Eagle's keyboard. It can be used with other keyboards (IBM's, for instance) but is best suited to the Eagle's. Eaglewriter uses explicit end-of-line marks and a large set of commands. It is very flexible in dealing with the printer. It has several kinds of global search and replacement commands, a real must for serious editing. Most important, Eaglewriter has a macro capability. Macros are stored sequences of commands that the user can create. Eagle supplies several macro packages that do such varied and useful things as mail merges, sorting, selective printing (printing a portion of the file), multifile printing, boilerplate letters, and filling in forms. Macros are usually seen only on mainframe computers or expensive professional workstations, though they are becoming more popular on personal computers. It is very encouraging to see that Eaglewriter is equipped with such a powerful tool.

I was not too impressed with Eaglewriter's human interface, but I suspect this is a matter of taste rather than bad design. One slight drawback is the cumbersome way that Eaglewriter handles files larger than 16K bytes. Since handling files is a fairly mechanical operation (there is a 12-step procedure for it in the manual), the Eagle's designers might have let the program perform the operation for you. Unfortunately, they didn't.

Eaglecalc is a typical spreadsheet program designed to be compatible with the Eagle keyboard. It has a spreadsheet size of 255 rows by 64 columns. It performs adequately and has the right features, such as variable-width columns and formatting. It can be run independently of the Eagle keyboard, but it functions at its best with the dedicated function keys. It also has a fairly extensive Help utility.

Both Eaglewriter and Eaglecalc can be called via a menu that can be invoked by placing the proper disk in drive A and rebooting. The menu is somewhat useful for a novice user but very limited in function. The menu system has no provision for switching application programs short of rebooting. Each menu has a QUIT command that prints a message telling you to turn off the power and then paralyzes the processor. None of the menus has any provision for dropping into the DOS command processor (you can do it, but you have to type Control-C at exactly the right time). Unlike some other menu systems, this one is written as a binary program file, so it cannot be extended. Eagle does offer a program, Flex Menu, that lets you design your own menus, but it wasn't included in the package I tested.

System Support

For the novice user, the Eagle documentation is pretty good. Because it has a cookbook approach, you don't need much technical background to read it. In addition, the manuals are full of examples. However, no technical documentation is provided for advanced users.

Except for BASICA, all the IBM software at my disposal ran on the Eagle. This included the Multiplan spreadsheet, dBASE II, Peachtext, Wordstar, the Finalword, and Laboratory Microsystems' FORTH. Conversely, Eaglewriter and Eaglecalc both ran on the IBM PC. MS-DOS 2.0 also ran on the Eagle with no noticeable difficulties.

Eagle isn't the easiest company to deal with for user support. A call to the company's headquarters for technical answers involves a lot of time on hold and replies such as, "That's not my department, but I'll forward you to the XXX department." But there are people deep in the bureaucracy who know the answers to technical questions; it just takes patience to reach them.

Conclusion

The Eagle is a fairly acceptable machine. The problems with the display are slightly annoying but not enough to remove the machine from serious consideration as an alternative to the IBM PC. With the latest ROM set, the Eagle display should perform acceptably.

The Eagle keyboard is a more serious problem, but if you're doing only a small amount of typing, it might not present too much of a problem. For serious word-processing, database, and spreadsheet applications, you should seriously consider a better keyboard, such as an IBM or an IBM compatible. ■

Tom Wadlow is an engineer at the Lawrence Livermore National Laboratory. He can be reached at POB 2755, Livermore, CA 94550.

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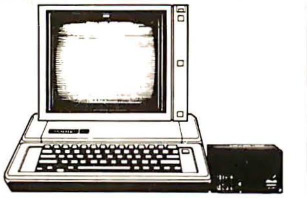
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STSC APL*PLUS and IBM PC APL

Two APLs for the IBM PC

by Jacques Bensimon

When details of the much-anticipated IBM Personal Computer (PC) were made public in 1981, I sadly joined the ranks of the crystal-ball gazers whose various predictions bit the dust that summer. You see, I had convinced myself that IBM was about to share with the world what often seems to be the computer industry's best-kept secret, namely that APL is one of the most powerful, expressive, and—not undesirable in the context of a personal computer—fun-to-use programming languages ever devised.

Looking back on it now, I suppose that it was extravagant of me to expect Big Blue to embrace APL as the premiere language for its PC while the rest of the microcomputer universe remained entrenched in BASIC. It was not unreasonable to expect, however, that IBM would at least include in the PC's character set the special symbols that are the hallmark of APL; this would have paved the way for headache-free design of APL interpreters for its new machine. IBM, after all, was an important (though at times unwilling) contributor to the development of APL in the mid-60s and remains to this day one of the language's most avid users; surely that called for encouragement of APL in the PC environment. And yet, as I stared at the Personal Computer's 256 characters, I could find no trace of most APL symbols among that dizzying collection of playing-card suits, happy faces, musical notes, and generally unusable mathematical symbols. I was not happy.

But time passes, wounds heal, life goes on, and I have forgiven IBM. I can afford to be magnanimous because the void caused by IBM's omission was quickly filled. First (in June 1982) came the University of Waterloo's microAPL, an offering intended for the educational market. Next out of the gate (in December 1982) came STSC Inc. with its ambitious APL*PLUS/PC Application Development System. STSC, a leading vendor of APL timesharing and consulting services, was already a supplier of APL-language processors for IBM mainframes, DEC VAX superminis, and, remarkably, Radio Shack TRS-80 Model III microcomputers. And most recently (in June 1983), IBM itself introduced a surprising Personal Computer APL System, the first major piece of software for the PC to come out of the halls of IBM.

It won't give away too much of the ending for me to tell you right off the bat that the news is mostly good: both STSC's APL*PLUS/PC and IBM's PC APL fully implement conventional APL's language component; differences between the two packages—and there are many—arise from language *extensions* to handle such things as report formatting and error trapping and from the mechanisms used to provide access to disk files, video screen, printers, and communication ports. (More on all this later.)

STSC's Version of APL

For the not-insignificant sum of $595, you can buy the APL*PLUS/PC Application Development System. It consists of a 5¼-inch disk in single-sided format (but recorded on both sides) that contains the APL interpreter and a collection of utility workspaces, a 24-pin ROM IC

At a Glance

Name
APL*PLUS/PC Application Development System release 1, version 2.6

Type
APL language interpreter

Manufacturer
STSC Inc.
2115 East Jefferson St.
Rockville, MD 20852
(301) 984-5000

Format
5¼-inch single-sided floppy disk and 24-pin ROM IC

Language
8088 machine language

Computer
An IBM Personal Computer (or PC XT) running PC-DOS version 1.1 or 2.0, with a minimum of 128K bytes of RAM, at least one disk drive (single- or double-sided) and an 80-column display (monochrome or color/graphics)

Documentation
A 450-page programmers reference manual, 8½ by 11 inches, in a 3-ring binder; a 170-page tutorial, APL Is Easy; and a 380-page textbook, APL: An Interactive Approach

Price
$595

At a Glance

Name
IBM Personal Computer APL System version 1.00

Type
APL language interpreter and auxiliary processors

Manufacturer
International Business Machines
POB 1328
Boca Raton, FL 33432
(305) 998-2000

Format
5¼-inch single-sided floppy disk

Language
8088 machine language

Computer
An IBM Personal Computer (or PC XT) running PC-DOS version 1.1 or 2.0, with a minimum of 128K bytes of RAM, at least one disk drive (single- or double-sided), an Intel 8087 numeric coprocessor and a 40- or 80-column graphics display

Documentation
A 370-page reference manual, 5½ by 8½ inches, in a 3-ring binder

Price
$195 (from IBM Product Centers; authorized IBM dealers might charge differently)

(read-only memory integrated circuit) providing the APL symbols, a plasticized card showing the keyboard location of the characters, and extensive documentation including a 450-page programmer's reference manual, a tutorial introduction, *APL Is Easy!*, and the classic textbook, *APL: An Interactive Approach* by Gilman and Rose (second edition revised, Wiley, 1976). The textbook makes frequent references to a now-defunct desktop APL computer called the IBM 5100; interestingly, the Personal Computer's lesser-known name is the IBM 5150.

STSC deserves high marks for its well-designed integration of APL with the PC. The custom ROM chip replaces the character-generator ROM on either the monochrome or the color/graphics display adapters mounted inside the PC's system unit. I found the replacement instructions clear and easy to follow; the entire procedure took less than 10 minutes. With the new ROM in place, about one-quarter of the PC's original characters (mostly the novelty and mathematical characters with 8-bit values in the range 0–31 or 224–255) give way to the missing APL characters; unaffected are the ASCII characters in the range 32–127, the line-drawing graphics, and most of the international accented letters and punctuation.

Beyond this unobtrusive addition of APL symbols to the PC, STSC seems to have put great thought into the environment presented to users of its system. The keys on the cursor pad and some of the Alt/function-key combinations allow you to move quickly around the screen, move to the beginning or end of a line, edit the contents of a line, insert or delete lines and characters, make one line a continuation of another, and break continued lines into two lines.

Flexibility in managing the display and the fact that the APL interpreter will process the screen line that contains the cursor when you press the Enter key make it very easy to modify, combine, and reenter previous inputs, to simulate full-screen editing of defined functions, and to store already displayed output in a variable as an afterthought. All of this encourages the experimental approach to APL programming, in which the germ of an idea gradually evolves into a complete algorithm with the computer itself helping you make design decisions along the way.

Before I discuss IBM's package, I'd like to offer a few more preliminary observations about STSC's APL in the PC environment. You can assign sequences of characters to the 10 function keys (as well as to the Shift/function-key and Ctrl/function-key combinations) by using the programs in the utility workspace MULTIKEY. You can choose to make the assignments last only for the duration of the current session or to make them permanent for a particular copy of the APL interpreter. Typical uses include storing often-needed commands or making available single characters (such as the line-drawing graphics) that cannot otherwise be entered from the keyboard. In practice, I found this feature be of limited usefulness: what we really need is a system function that allows us to define function keys from our own workspace as the need arises.

If you install an Intel 8087 Numeric Data Processor in

Benchmark		IBM PC APL (w/ 8087)	STSC APL*PLUS (w/ 8087)	STSC APL*PLUS (w/o 8087)	Advanced BASIC (8087 N/A)
1. Plus Reduction	Z←+/VI	90 msec.	102 msec.	157 msec.	1155 msec.
2. Logical Reduction	Z←∨/VL	0.4	3	N/C	-
3. Maximum Reduction	Z←⌈/[1]MI	40	25	N/C	660
4. Exponentiation	Z←VI*.1	390	282	2466	3781
5. Absolute Value	Z←|VR	80	79	130	1007
6. Indexing	Z←VR[VI[⍳20]]	20	14	N/C	114
7. Sorting	Z←VI[⍋VI]	600	112	N/C	-
8. Take	Z←¯2 1↑MR	9	24	N/C	-
9. Membership	Z←VI∊VI	150	146	N/C	105215
10. Transposition	Z←2 1⍉MC	450	60	N/C	-
11. Outer Product, Characters	Z←VC∘.=VC	360	141	N/C	-
12. Outer Product, Integers	Z←(⍳50)∘.+⍳50	2530	439	N/C	13169
13. Inner Product, Reals	Z←VR⌊.+VR	210	341	546	2012
14. Matrix Division	Z←MR⌹10↑VR	70	1488	2206	-
15. Fibonacci Series	Z←1 1 L:→(100>⍴Z←Z,+/¯2↑Z)/L	2200	3827	3943	832
16. Multiplication	Z←VR×3.14	100	136	468	1314
17. Division	Z←VR÷3.14	110	142	724	4653
18. Logarithm	Z←⍟VR	150	143	5094	2394
19. Sine	Z←1○VR×.1	411	438	12009	3913
20. Sieve of Eratosthenes	(Listing 2)	1680 sec.	1693 sec.	N/C	1722 sec.
21. Chess Problem	(Listing 3)	33.316 min.	28.345 min.	N/C	-

Note 1: The times given for benchmarks 1-19 are in milliseconds and are adjusted to represent one execution of the given expression (net of looping overhead).

Note 2: The variables used in benchmarks 1-19 are defined by

```
MI←10 10⍴VI←(500⍴0 1 0 0 1)/⍳500
VL←1 0 1 1 0 0 0 1
MR←10 10⍴VR←VI+0.1
MC←26 26⍴VC←'ABCDEFGHIJKLMNOPQRSTUVWXYZ'
```

Note 3: The times given for benchmark 20 are in seconds and represent ten executions of the programs in Listing 2.

Note 4: The times given for benchmark 21 are in minutes and represent one execution of the function FMATE of Listing 3 with left argument 2, right argument (7⍴0),¯3 ¯4 ¯4 ¯3,(10⍴0),¯1,(14⍴0),5 0 ¯1 0 ¯6 ¯1 1 ¯1 0 0 1 0 ¯1 2 0 6,(4⍴0),1,12⍴0 and global variables A and B set to 1 and -1 respectively.

Table 1: *Twenty-one benchmarks for the two versions of APL. "N/C" (no change) and " - " denote benchmark tests that were not run. Benchmark 21 solves the chess problem in the text on page 256.*

your PC, APL*PLUS/PC will automatically take advantage of the coprocessor to accelerate all floating-point computations. If you choose not to use the 8087 (the chip currently costs anywhere from $200 to $260, and IBM Product Centers sell an 8087/8088 matched pair for $260), the interpreter will use software floating-point routines to provide the same range and precision at the expense of speed. The benchmark timings in table 1 may help you decide whether you can live with the difference.

IBM's Version of APL

In the other corner, weighing in at a modest $195, the pride and joy of the IBM Madrid Scientific Center: the IBM Personal Computer APL System. It comes boxed in the obligatory (and rather pleasant) 8- by 9½-inch format and consists of a single-sided 5¼-inch disk, a set of keytop decals, and a 370-page reference manual. (The manual is good but will not teach you the language; buy *APL: An Interactive Approach.*) However, this implementation *requires* an 8087 chip, significantly increasing its price for most users.

IBM's integration of APL with the PC falls far short of STSC's: because no ROM character generator is provided (I hope all you add-on manufacturers out there are paying attention), APL characters can be displayed only if your system has the color/graphics adapter and





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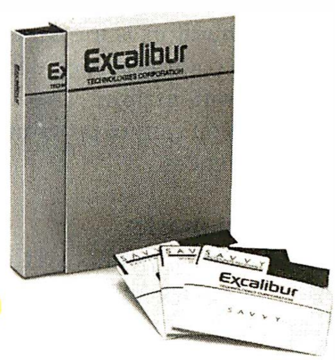
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The Origins of APL

The acronym APL derives from the title of the book A Programming Language *(Wiley, 1962) by Dr. Kenneth Iverson, then an applied mathematician at Harvard University. Finding that standard mathematical symbolism was inadequate for communicating the results of his studies of sorting and other algorithmic processes, Iverson developed his own concise and consistent notation for the description of solution procedures.*

Iverson's Notation, as APL was then known, was not originally meant to be a computer programming language; it evolved into one during the years Iverson spent refining his creation at the IBM Thomas J. Watson Research Center. It was there in 1965 that the first experimental APL interpreter was completed for use in Iverson's research. APL's interactive design was so successful that use of the interpreter quickly grew to include helping out with the day-to-day work of the research center staff. With its fame spreading by word of mouth, it wasn't long before APL had become an underground sensation throughout IBM. Dubbed APL\360, a version of the interpreter was eventually released to interested outside organizations, primarily universities and timesharing companies. Two of the timesharing firms, I.P. Sharp Associates (where Iverson currently continues his research) and Scientific Time Sharing Corporation (now STSC Inc.), have since then played an important role in shifting APL from the scientific to the commercial world, primarily through the addition of an integrated file system, a powerful formatting facility, and exception-handling (error-trapping) features.

a graphics monitor. If you prefer the high resolution of the monochrome adapter and display, you'll have to mentally map the mathematical and international characters that appear on your screen into their corresponding APL characters; this actually isn't too bad because, in assigning the correspondence, IBM took advantage wherever possible of similarities between APL symbols and original PC characters.

To further confuse the character-set issue, the internal APL 8-bit representation of the 256 characters (i.e., the order in which they appear in the atomic vector ⎕*AV*) is not documented and bears no resemblance to the display representation mentioned above—in other words, it makes no attempt to look like ASCII (American National Standard Code for Information Interchange) code. This adds all kinds of needless translation difficulties to the use of files, printers, and communication ports. The keytop decals are a nice touch: they require patience to install, but once in place they show clearly the location of APL characters on the keyboard.

IBM's APL provides a limited but still very useful capability to modify and reenter any line appearing on the screen. Lines entered from the keyboard are restricted to 80 characters (with no continuation allowed), and there are no provisions for recalling the last input line to the display when it has scrolled off the top. A handy feature for those who have both monochrome and color/graphics monitors is the capability to switch from monochrome to color/graphics with the press of an Alt/function-key combination. This is the only use of the function keys: you cannot program them with your own character sequences.

The Benchmarks

I have already mentioned that these two packages offer all the language-related features commonly found in APL systems. But before I turn to extensions and system-related features, I'll deal with two questions about the language aspect: How accurate are the implementations, and how fast are they?

After several weeks of using the two systems, I have yet to run across a single instance of a primitive function not returning a correct result when presented with valid arguments. STSC's APL, however, does tend to be too lenient, sometimes returning a result when the arguments to a function are invalid. For example, the use of transposition in listing 1 should have caused a DOMAIN ERROR message. Unless your algorithms hinge on the occurrence of certain errors (not a good practice), this kind of bug should not be a problem.

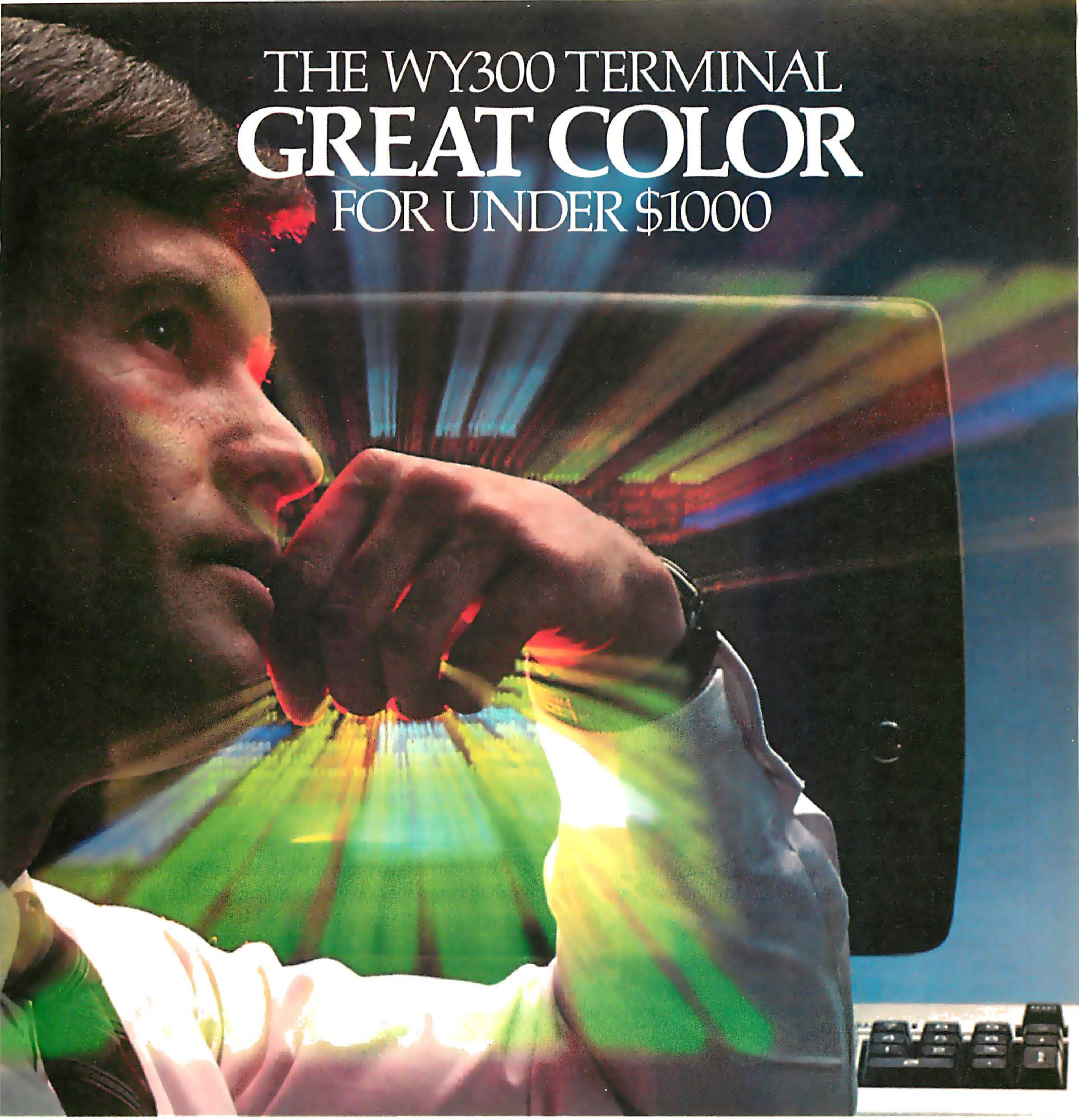
I used a set of 21 benchmarks to compare the speeds of the two packages; table 1 summarizes the results. Each benchmark was run under IBM's APL (necessarily with the 8087 coprocessor), STSC's APL*PLUS (with and without the 8087), and, in some cases, IBM's Advanced BASIC (which cannot use the 8087). I excluded from BASIC those benchmarks that I considered awkward in the language, such as those involving character data (which is treated differently in BASIC), the sorting and matrix division benchmarks (which are not primitives in BASIC and depend critically on the algorithms used), and the chess-problem benchmark (which I'm not being paid enough to attempt in BASIC).

Benchmarks 1 through 15 have been floating around APL literature for years and crop up often in manufacturers' advertising. I added benchmarks 16 through 19 to further exercise the floating-point capabilities of the packages. The times shown in table 1 for these benchmarks represent single executions of the expressions but are based on 100 consecutive repetitions; they are adjusted to nullify the effects of the required looping.

Benchmark 20 is the prime-number-generating Sieve of Eratosthenes. The January 1983 BYTE (page 290) contained an APL version of the benchmark that did not faithfully apply the algorithm described by the authors of the article (and gave incorrect results to boot). A letter published in the May 1983 issue (pages 8-9) offered a correct APL solution but used a significantly modified algorithm to reduce execution time, which goes against the spirit of benchmarking. Listings 2a and 2b present the APL and BASIC programs that I used in my timings. Note that to be consistent with results previously published by BYTE, the times shown in table 1 for this benchmark represent 10 executions of the programs.

Benchmark 21 is the solution of the chess problem (see the text box on page 256) using the APL functions in

Text continued on page 254



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A Brief Look at APL

When using APL, you are essentially interacting with a very powerful programmable calculator: you enter a valid APL expression, hit the Return key, and the answer (if any) is displayed starting on the next line; for example,

```
      3×4
12
      3÷4
0.75
```

Notice that entries are indented six spaces to distinguish them from the computer's answers and that no explicit command is required to have results displayed. The number of operations, or *primitive functions*, available in the language is very large; other examples include

```
      2*3
8
      5⌊8
5
      5⌈8
8
      5|28
3
      3>5
0
      'A'≠'B'
1
```

These illustrate, respectively, the *exponentiation*, *minimum*, *maximum*, *residue* (or remainder), *greater than*, and *not equal to* functions. You can see from the last two examples that the comparison functions return the numeric values 1 or 0 to represent logical true or false.

The examples so far have shown functions that operate on two objects, their so-called *left* and *right arguments*; they are known as *dyadic* functions. There are also *monadic* functions that operate on a single (right) argument. The examples

```
      ÷4
0.25
      *1
2.718281828
      ⌊5.8
5
      !4
24
      ~0
1
```

illustrate the *reciprocal*, *exponential*, *floor* (or integer part), *factorial*, and *logical negation* functions.

Because the number of primitive functions is so large and because you can define your own, functions in an APL expression are executed in the order in which they are encountered going from *right to left* across the line, except as modified by parentheses:

```
      9-2×5-3
5
      9-(2×5)-3
2
      (9-2)×5-3
14
```

The seemingly strange choice of right-to-left execution stems from the desire to have a monadic function's argument appear on its right, where it belongs naturally, while keeping the design of the interpreter simple and efficient.

I intentionally used the vague term *object* when referring earlier to the right or left argument of a function. A lot of the power of APL derives from the fact that these objects need not be single numbers (*numeric scalars*) or single characters (*character scalars*) but can in fact be entire vectors, matrixes, or higher-dimensional arrangements of numbers (*numeric arrays*) or characters (*character arrays*). Unlike other languages, APL treats arrays as wholes, accepting them as arguments and returning them as results:

```
      1 3.2 5 7 + 2 4 6 8.4
3 7.2 11 15.4
      'ABBE!' = 'ABLE?'
1 1 0 1 0
```

You can assign a name to an array without, as in other languages, having to first declare its type and shape to reserve its storage; APL manages all available memory space and allocates it dynamically. The *assignment* function (denoted by the left-pointing arrow) attaches the name on its left to the array on its right:

```
S←6.28÷2
V←'JOSEPH'
MAT←3 3⍴VEC←1 ¯1 2 2 0 6 3 ¯1 9
S
3.14
      V
JOSEPH
      VEC
1 ¯1 2 2 0 6 3 ¯1 9
      MAT
 1 ¯1 2
 2  0 6
 3 ¯1 9
```

The following examples use the variables defined above to illustrate, without additional comment, some of the many other primitive functions that APL provides for the manipulation of arrays:

```
      ⍴V                          (shape)
6
      ⌽V                          (reverse)
HPESOJ
      2⌽V                         (rotate)
SEPHJO
      V[1 2 4]                    (index)
JOE
      1 0 1 0 1 1/V               (compress)
JSPH
      V←V,' IS HERE'              (catenate)
      V
JOSEPH IS HERE
      ⍴V
14
      +/VEC                       (sum)
21
      +\VEC                       (running sum)
1 0 2 4 4 10 13 12 21
      ⌊/VEC                       (minimum)
¯1
      ⌈\VEC                       (running maximum)
1 1 2 2 2 6 6 6 9
      ⍋VEC                        (grade up)
2 8 5 1 3 4 7 6 9
      SORTEDVEC←VEC[⍋VEC]         (sort)
      SORTEDVEC
¯1 ¯1 0 1 2 2 3 6 9
      5↓SORTEDVEC                 (drop)
2 3 6 9
      ¯3↑SORTEDVEC                (take)
3 6 9
      ⍴MAT
3 3
      ⌽MAT                        (reverse)
 2 ¯1  1
 6  0  2
 9 ¯1  3
      ⊖MAT                        (reverse)
 3 ¯1  9
 2  0  6
 1 ¯1  2
      ⍉MAT                        (transpose)
 1  2  3
¯1  0 ¯1
 2  6  9
      MATINV←⌹MAT                 (matrix inverse)
      MATINV
 3    3.5 ¯3
 0    1.5 ¯1
¯1   ¯1    1
      MAT+.×MATINV                (matrix multiplication)
1 0 0
0 1 0
0 0 1
```

Programming in APL is the process of creating new functions. These *user-defined functions* are denoted by names rather than by symbols but are otherwise used just like primitive functions. They can be monadic, dyadic, or even *niladic* (requiring no arguments) and may or may not return a result. You indicate to APL that you wish to temporarily leave *calculator mode* and go into *function-definition mode* by typing the triangular *del* character followed by a *function header*. The function header is APL's only declarative statement; it specifies the function's name, its syntax (the number of arguments it requires and whether or not it returns a result), and the names of any temporary local variables it uses. While you're in function-definition mode, APL prompts you with bracketed line numbers and then records (rather than acts upon) the statements that you enter. You have already seen two of APL's three types of executable statements: the assignment, which does not display a result, and the APL expression not ending with an assignment, which does display its result (if any). The third type of statement is the *branch* (denoted by the right-pointing arrow), which can alter the top-to-bottom sequence of execution of a defined function's lines by directing execution to a given line.

APL work is organized around the concept of the *workspace:* the *active workspace* is that portion of the computer's memory in which all of the functions and variables you create are stored and in which all of the computations you request take place. You may, at any time during your APL session, have the current contents of the active workspace preserved in secondary storage as a named *saved workspace* (which usually appears as a file on your disk). Once saved, a workspace can be reactivated (loaded) at a later time, thus restoring the active workspace to its original state, or its contents (variables and functions) can be selectively copied into the current active workspace. An APL application usually consists of a saved workspace containing all of the pertinent functions and variables along with a *latent expression*, a special vector containing the character representation of an APL statement to be executed automatically as soon as the saved workspace is loaded. The latent expression will typically initiate execution of the application's master function.

Most APL implementations provide a battery of so-called *system commands* to manage the saving, loading, copying, and erasing of workspaces and to make possible examination and control of their contents. These system commands are not, strictly speaking, part of the APL language and therefore cannot be lines in defined functions. The trend in recent years has been for APL systems to provide *system functions* that duplicate the action of system commands and can be used under program control.

The language has two advantages that cannot be readily conveyed by a quick printed tour of its facilities. One is the ease with which you can learn the language: the simplicity of APL syntax, the absence of red tape in using arrays, and the immediate feedback of calculator mode combine to provide an environment in which you can freely experiment with language features, concentrating at first on a few functions and gradually building up your repertoire. The second advantage is the sense of programming confidence that you will experience as a user of APL. The power and versatility of the language encourage you to tackle even the most difficult tasks with the knowledge that the step between a mental solution and a computer solution is a short one. APL drastically reduces programming time because a verb-oriented oral description of an algorithm can often be immediately written down as a function-oriented APL expression. This leads to terse programs and explains the often-heard criticism that APL is unreadable. APL is in fact quite readable, but you should not expect to grasp at a glance the meaning of a line of APL any more than you would a pageful of BASIC or five pages of COBOL.

Text continued from page 250:

listing 3. I include it in this review for two reasons: first, because it involves the cooperation of several functions, one of which (FMATE) is recursive, it gives a thorough workout to the systems' function-calling mechanism (with the associated stacking of the execution environments and creation of local variables); second, it provides a good example of APL's capability to make short work of a relatively complex programming problem. I spent more time selecting data structures than I spent actually writing code for the functions, with the entire process taking about 10 hours. With most programming languages, this recreational exercise would have been a major project.

Now, what are we to make of the results of all these benchmarks? If you consider speed to be the deciding factor in choosing between the IBM and STSC APL systems, you'll find no final pronouncement here. I'm calling it a draw. IBM showed up slightly faster in the simple arithmetic benchmarks (with the exception of exponentiation), quite a bit faster in the inner product and heavily-looping Fibonacci series benchmarks, and shockingly faster in the matrix division benchmark. STSC, on the other hand, did much better in the categories of indexing, sorting, transposition, and outer product, and put it all together to come out on top in the grueling chess-problem marathon. If nothing else, these timings point out where the authors of the packages chose to cut corners: it is a fairly common practice in designing APL interpreters to implement some primitive functions (especially those considered infrequently used) as a combination of calls to other already-coded functions, which essentially means that those functions are written not in assembly language but rather in a subset of APL. I would guess that this was the fate of STSC's matrix division primitive and of IBM's outer product, dyadic transposition, and maybe even grading (sorting) primitives.

Without the 8087 coprocessor, STSC's APL still performed quite acceptably in the floating-point benchmarks; the difference became painful only in the case of logarithmic and trigonometric functions. The multiplication, division, and exponentiation benchmarks were slowed down by factors of about 3, 5, and 9, respectively. That's a far cry from the factors 78, 82, and 170, which represent the published relative speeds of the 8087 and the 8088 performing single instances of those same double-precision operations. This is probably due to the fact that, overall, the 8088 spends the majority of its time retrieving operands from memory and storing results back into memory. Nevertheless, if your applications tend to be numerically oriented, the coprocessor is likely to be a good investment.

As for BASIC, although it did very well in the Fibonacci series benchmark and held its own in the Sieve of Eratosthenes (both of which involve a lot of looping), it ran out of breath trying to keep up with APL's easy handling of array operations in the other benchmarks. BASIC's apparent superiority over STSC's APL without the 8087 in the logarithmic and trigonometric benchmarks is a result of the fact that version 1.1 of BASIC calculates such functions to single precision only, less than half the accuracy of STSC's software emulation of the 8087.

Listing 1: *An example of STSC APL code that should have caused a domain error but didn't.*

```
        ⎕IO←1
        0 1 ⍉ 2 2⍴⍳4
1 2
```

Listing 2: *The prime-number-generating Sieve of Eratosthenes (using the algorithm originally described in* BYTE*) in APL (listing 2a) and BASIC (listing 2b).*

(2a)

```
    ∇ PRIMES
[1]    I←1 ◇ F←(8191⍴Y),E
[2]   Y:F[I+P×⍳⌊(8191-I)÷P←1+I+I]←N
[3]   N:→F[I←I+1]
[4]   E:(⍕Y+.=F),' PRIMES'
    ∇
```

(2b)

```
10   DEFINT A-Z
20   OPTION BASE 1
30   DIM F(8191)
40   C=0
50   FOR I=1 TO 8191
60     F(I)=1
70   NEXT I
80   FOR I=1 TO 8191
90     IF F(I)=0 GOTO 170
100    P=I+I+1
110    K=I+P
120    WHILE K<=8191
130      F(K)=0
140      K=K+P
150    WEND
160    C=C+1
170  NEXT I
180  PRINT C;" PRIMES"
190  END
```

Other Features

To be great, an APL system must provide many facilities beyond the language itself. This is especially true of an APL system running in a microcomputer environment, where users expect to have direct control of the hardware and where there's a need to support a wide array of peripheral devices. I'll discuss STSC's and IBM's efforts in this direction under several broad headings.

Workspace size: Your workspace under STSC's APL can be as large as your machine's total memory minus an interpreter and operating-system overhead of approximately 90K bytes. A parameter on the operating system command that starts up APL even allows the interpreter to use memory beyond the 544K-byte maximum recog-

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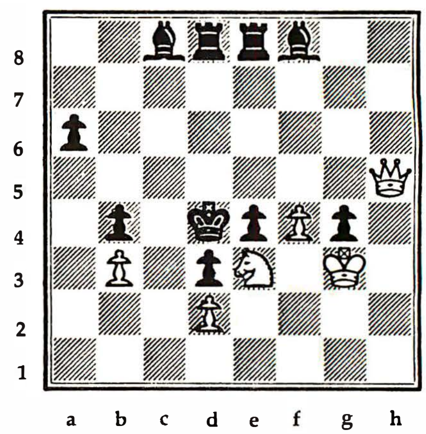
Notes on the Chess Benchmark

Given sufficient time, this set of five functions (see listing 3) will solve any chess problem that ends in checkmate, including problems that involve castling, en-passant capture, or under-promotion of a pawn to a knight. WSINIT must be run once to define some global variables.

To solve a problem, assign to variable A the attacking color and to B the defending color (White = 1, Black = −1), and then run FMATE. The left argument of FMATE is the maximum number of moves to mate, and the right argument is a 69-element numeric vector representing the position. The first element is either 0 or the square number on which an en-passant capture can take place on the next move. Squares are indicated in algebraic chess notation (e.g., c5 is 35 and f2 is 62). The next four elements are either 1 or 0 to indicate whether or not castling is still possible (in the order White queen- and king-side, then Black queen- and king-side). The remaining 64 elements are the contents of the chessboard from the top left corner to the bottom right corner as seen from White's side (0 = empty, 1 = pawn, 2 = knight, 3 = bishop, 4 = rook, 5 = queen, 6 = king, positive for White, and negative for Black).

The result of FMATE is a two-element numeric vector that contains, if a solution is found, the "from" and "to" square of the winning move (in algebraic notation, with a negative "to" square indicating pawn-to-knight promotion); or, if no solution is found, either 0 1 or 0 0 (0 0 indicates that the attacker has no legal move in the given position).

The functions should run in any APL system if statements using the diamond separator are broken up into several lines and if the sequence ",[0]" is substituted for the hyphen-comma overstrike character (as in lines 5 through 9 of function MLIST). I'd be interested in timings of the benchmark problem on hardware more powerful than the PC (see note 4 in table 1 for its definition, and expect the solution 85 15). FMATE makes no attempt to examine potential moves in an intelligent order and can take a long time to execute.



The chess position used in benchmark 21; see table 1 and listing 3. White is to move and checkmate in 2.

nized by version 1.1 of DOS (disk operating system). Under IBM's APL, all memory up to the 544K-byte maximum can be used, with system overhead ranging between 84K and 113K bytes, depending on which *auxiliary processors* (APs) you choose to load. (I'll be coming back to the subject of APs later on.)

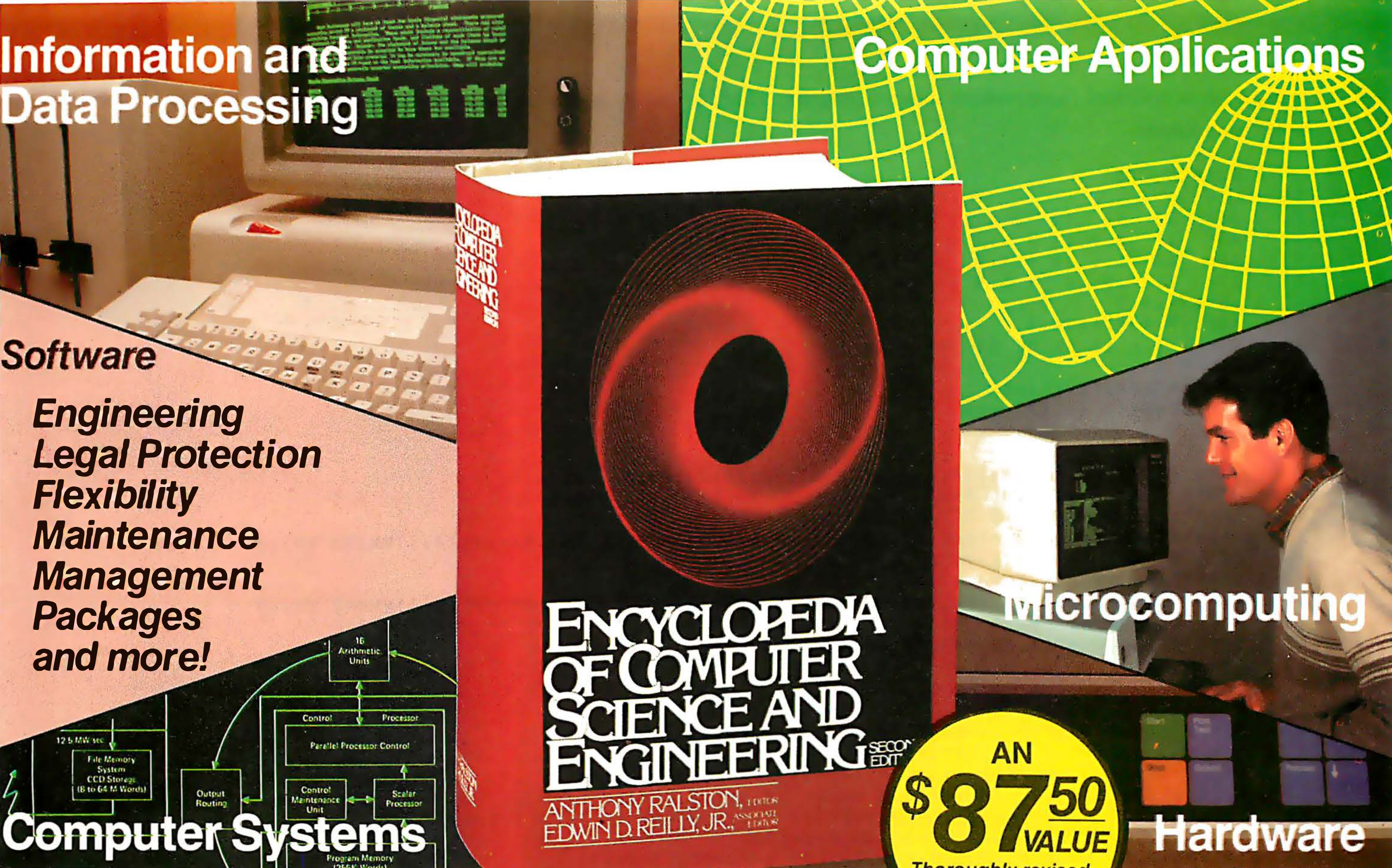
There is, however, a twist to IBM's use of memory: the first 64K bytes of the active workspace constitute what IBM calls the *main workspace*; whatever is left over is labeled the *elastic workspace*. All real APL work, like statement execution or the creation and modification of APL arrays and functions, takes place in the main workspace; the interpreter uses the elastic workspace strictly for the temporary storage of APL objects when space is needed for an operation in the main workspace. I find this quasi-virtual memory scheme a rather timid way for IBM to deal with the segmented architecture of the 8088 microprocessor.

Although the shuttling of data between the main and elastic workspaces is not usually noticeable, this arrangement does have some drawbacks: IBM APL arrays are limited to 32K bytes, and certain operations (such as adding two large numeric vectors) cannot be carried out because of the need for both the arguments and the result to fit simultaneously in the 64K-byte main workspace. (Under STSC's APL, an array can occupy a full memory segment, or 64K bytes, and as long as there is room in memory for the result, operations between large arrays can take place.)

Report formatting: STSC's APL*PLUS offers the powerful and much-imitated ⎕*FMT* formatting function. Its capabilities are too numerous to detail here (as witness the fact that STSC offers a separate manual on its use), so I'll limit myself to the example given in listing 4a. STSC also provides the utility workspace FORMAT containing a set of rather slow functions that simplify adding titles, column headings, and row names to reports being formatted with ⎕*FMT*.

IBM's APL offers Picture Format, an extension to the simple dyadic format available on all APL systems. Picture Format has for many years been discussed and refined by various authors within IBM, and the result of all this work is a facility that cannot hold a candle to STSC's good old ⎕*FMT*; listing 4b shows an example of its use. Not only is Picture Format of limited capability (e.g., it is unable to duplicate the first example with its different floating decorators for positive and negative numbers), but it is also hard to learn because it attaches various unintuitive meanings to the digits that appear in the picture argument. All I can say for Picture Format is that it's better than nothing. (Note: You must specify your intention to use Picture Format when you load IBM's APL from DOS; it'll cost you an extra 7.6K bytes of overhead.)

Text continued on page 260



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Listing 3: *A complicated chess-problem solution program, FMATE, and its associated functions (subroutines). See the text box on page 256 for more details.*

```
     ∇ WSINIT;⎕IO
[1]    ⎕IO←1
[2]    ∆N← ¯21 ¯19 ¯12 ¯8 8 12 19 21
[3]    ∆B← ¯11 ¯9 9 11 ∘.×⍳7
[4]    ∆R← ¯10 ¯1 1 10 ∘.×⍳7
[5]    ∆K← ¯11 ¯10 ¯9 ¯1 1 9 10 11
[6]    ∆Q←∆K∘.×⍳7
[7]    ∆A←,(⌽⍳8)∘.+10×⍳8
[8]    ∆C← 4 2 ρ 11 51 81 51 18 58 88 58
[9]    ⎕IO←0
[10]   ∆F←(~∆F∊∆A)/∆F←⍳100
[11]   ∆Z←100ρ64 ◇ ∆Z[∆A]←⍳64
     ∇

     ∇ MA←M FMATE BD;KA;KB;L;N;LA;LB;SA;SB;IA;IB;FA;FB;BA;BB;MB;⎕IO
[1]    ⎕IO←0 ◇ KA←''ρKB←∆A[¯5+BD⍳6×A,B] ◇ KB←KB[1] ◇ L←0=N←M-1
[2]    LA←''ρρSA←A MLIST BD ◇ IA←¯1 ◇ FA←0
[3]   A:→(LA=IA←IA+1)ρD ◇ →((B,(KA,MA[1])[KA=MA[0]])SCHECK BA←(MA←SA[IA;])MMAKE BD)ρA
[4]    FA←1 ◇ →L↓X ◇ →((A,KB)SCHECK BA)↓A
[5]   X:LB←''ρρSB←B MLIST BA ◇ IB←¯1 ◇ FB←0
[6]   B:→(LB=IB←IB+1)ρC ◇ →((A,(KB,MB[1])[KB=MB[0]])SCHECK BB←(MB←SB[IB;])MMAKE BA)ρB
[7]    →LρA ◇ →(0=1ρN FMATE BB)ρA ◇ FB←1 ◇ →B
[8]   C:→(L∨FB)ρ0 ◇ →((A,KB)SCHECK BA)ρ0 ◇ →A
[9]   D:MA←0,FA
     ∇

     ∇ ML←TN MLIST BD;P;T;L;PW;∆P;LS;LO;LE;PS;TS;SW;I;⎕IO
[1]    ML← 0 2 ρ⎕IO←0 ◇ PW←(TN≠1)⌽ 2 7 ◇ ∆P←TN× ¯9 11 1 2
[2]    LS←LO←100ρ1 ◇ LS[∆F,PS←(L←TN=T←×P←5↓BD)/∆A]←0 ◇ TS←(|L/P),0
[3]    LO[(T=-TN)/∆A]←0 ◇ LE←LS∧LO ◇ →(SW←0,P,N,B,R,Q,K)[TS[I←0]]
[4]   P:T←((LO[2ρT]≤BD[0]=2ρT),∧\LE[2↓T])/T←P+(3+1ρL←PW=10|P←PS[I])ρ∆P
[5]    ML←ML⍪P,[0.5]T,-L[1]/T ◇ →SW[TS[I←I+1]]
[6]   N:ML←ML⍪P,[0.5]LS[T]/T←100|∆N+P←PS[I] ◇ →SW[TS[I←I+1]]
[7]   B:ML←ML⍪P,[0.5](,∧\LS[T]∧1,LO[0 ¯1 ↓T])/,T←100|∆B+P←PS[I] ◇ →SW[TS[I←I+1]]
[8]   R:ML←ML⍪P,[0.5](,∧\LS[T]∧1,LO[0 ¯1 ↓T])/,T←100|∆R+P←PS[I] ◇ →SW[TS[I←I+1]]
[9]   Q:ML←ML⍪P,[0.5](,∧\LS[T]∧1,LO[0 ¯1 ↓T])/,T←100|∆Q+P←PS[I] ◇ →SW[TS[I←I+1]]
[10]  K:T←LS[T]/T←∆K+P←PS[I] ◇ →(⍱/L←BD[2 3 -TN])ρY ◇ →(⍱/L←L∧(∧/LE[P- 10 20 30]),∧/LE[P+ 10 20])ρY
[11]   →(((-TN),P)SCHECK BD)ρY ◇ →L[0]↓X ◇ T←T,(((-TN),P-10)SCHECK BD)↓P-20 ◇ →L[1]↓Y
[12]  X:T←T,(((-TN),P+10)SCHECK BD)↓P+20
[13]  Y:ML←ML⍪P,[0.5]T ◇ →SW[TS[I←I+1]]
     ∇

     ∇ NB←MV MMAKE BD;UP;FT;P;⎕IO
[1]    UP←MV[1]<⎕IO←0 ◇ NB←5↑BD ◇ BD←5↓BD ◇ FT←∆Z[MV←|MV] ◇ BD[FT]←0,P←BD[FT[0]] ◇ →(1 6 =|P)/P,K
[2]   E:NB[0,(∨/∆C∊MV)/ 1 2 3 4]←0 ◇ NB←NB,BD ◇ →0
[3]   K:→(20≠|-/MV)ρE ◇ BD[FT]←⌽BD[FT←FT[1]+1,¯1-2=8|FT[1]] ◇ →E
[4]   P:→(2≠|-/MV)ρX ◇ NB[0]←MV[0]+×P ◇ NB←NB,BD ◇ →0
[5]   X:→(NB[0]≠MV[1])ρY ◇ NB[0]←BD[FT[1]+8××P]←0 ◇ NB←NB,BD ◇ →0
[6]   Y:→(1 8 ∧.≠10|MV[1])ρE ◇ BD[FT[1]]← 5 2 [UP]××P ◇ →E
     ∇

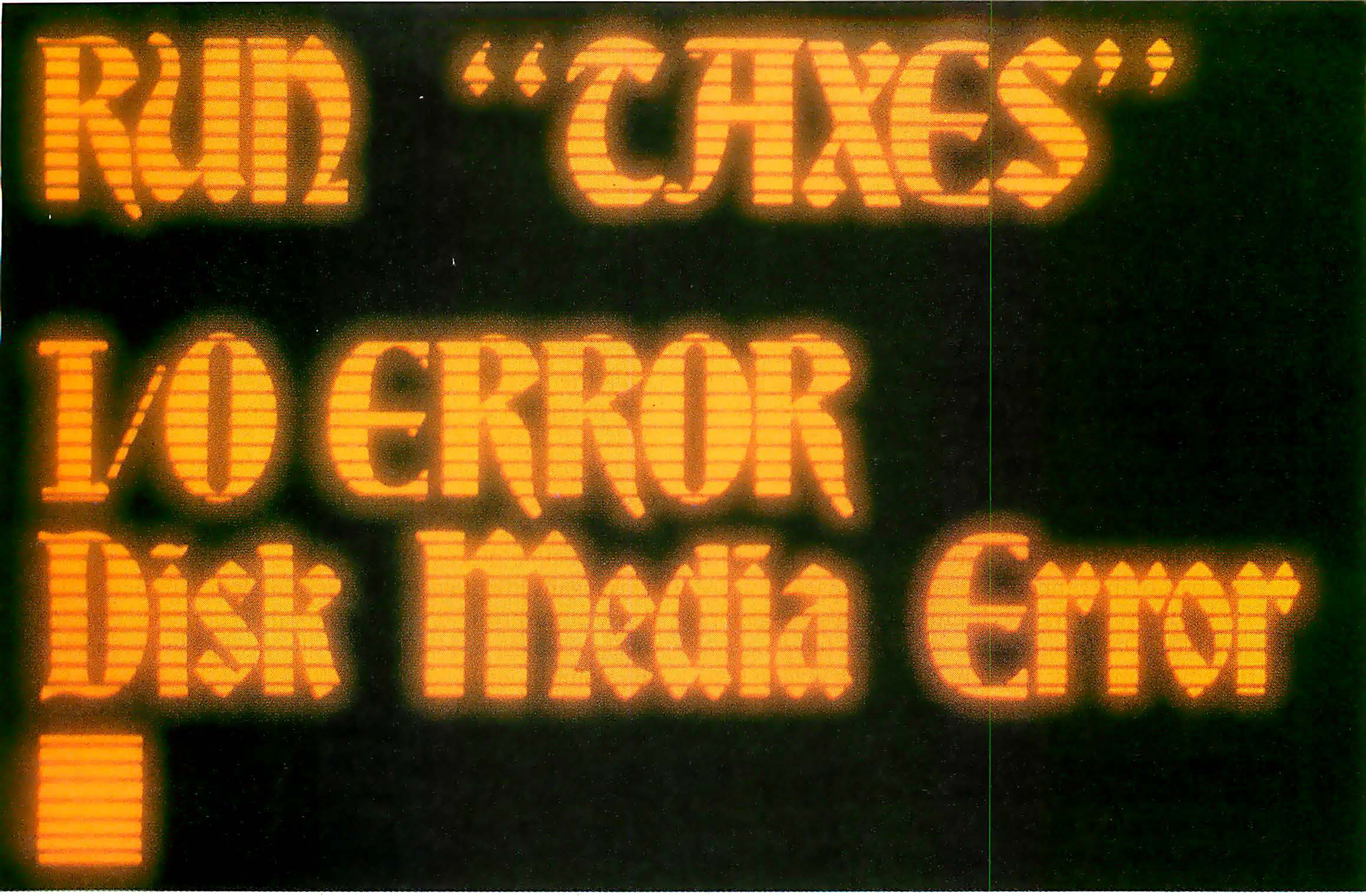
     ∇ YN←CS SCHECK BD;PS;P;LE;T;⎕IO
[1]    BD←5↓BD,⎕IO←0 ◇ PS←CS[0]×⍳7 ◇ P←CS[YN←1]
[2]    →(PS[1]∊BD[∆Z[P+CS[0]× ¯11 9]])ρ0
[3]    →(PS[2]∊BD[∆Z[100|P+∆N]])ρ0
[4]    LE←100ρ1 ◇ LE[∆F,(0≠64ρBD)/∆A]←0
[5]    →(∨/PS[3 5]∊BD[∆Z[(,∧\1,LE[0 ¯1 ↓T])/,T←100|P+∆B]])ρ0
[6]    →(∨/PS[4 5]∊BD[∆Z[(,∧\1,LE[0 ¯1 ↓T])/,T←100|P+∆R]])ρ0
[7]    YN←PS[6]∊BD[∆Z[P+∆K]]
     ∇
```

Listing 4: *A formatted output in APL. Listing 4a shows an example of the powerful STSC APL formatting function. Listing 4b shows the less powerful IBM APL Picture Format option.*

(4a)

```
      D←82679 10582 121383
      A←1234.567 0 ¯98765.4
      F←'G<Z9/99/99>,P<$>Q< >M<($>N<)>O<ZERO >F13.2'
      F ⎕FMT (D;A)
  8/26/79   $1,234.57
  1/05/82        ZERO
 12/13/83 ($98,765.40)
```

Listing 4 continued on page 260



A Modern Day Fable.

Once upon a time there was a very diligent man, Jack. Every year the man promised his very faithful wife that he would keep accurate records to make tax time more bearable.

One sunny day, Jack traded in his family cow for a new computer. That starry night, he began to enter all of his tax records onto disk. "How easy and accurate this will be," he stated.

The months went by. Tax time approached. Confidently, Jack inserted his data file and entered "Run Taxes." "Just watch," he said to his wife. But alas. His CRT, as if it were alive, proclaimed, "I/O ERROR." "Gads," he stammered in frustration. "Oh my," said his wife.

Then entered his neighbor carrying three beans, a golden lyre and the new Discwasher® Clean Runner™ Interactive Drive Cleaner. The good neighbor told Jack, "Preventive maintenance will destroy dirt in the disk drive and keep it running clean."

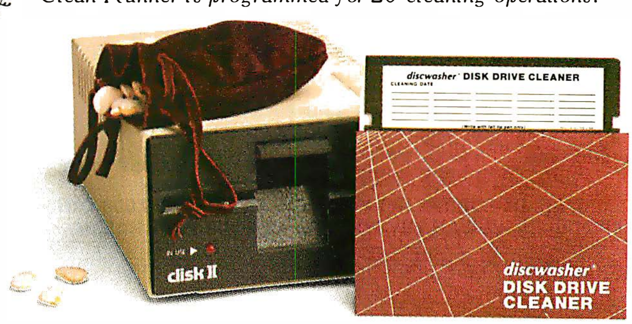
The good neighbor promptly inserted the Clean Runner Interactive Drive Cleaner into the drive and cleaned the read/write heads for Jack. Saying "Bye," he left to tend to his garden. Diligent Jack then proceeded to run his tax data and this time all went well.

The moral of the story, Discwasher Clean Runner is a disk of prevention for a bit of frustration.

The End.

Not all endings are that happy. A dirty read/write head can cost not only many hours of time but also the loss of valuable data.

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- *Clean Runner is an interactive system. It responds to your individual entries as it leads you step-by-step through the cleaning process.*
- *Clean Runner directs the head(s) of your drive to a different track for each cleaning. Clean Runner provides a contamination-free cleaning surface.*
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- *Clean Runner is programmed for 20 cleaning operations.*



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Listing 4 continued:

(4b)

```
      '55/05/05   (55,551.50)' ⍕ D,[1.5]A
 8/26/79      1,234.57
 1/05/82           .00
12/13/83    (98,765.40)
```

Text continued from page 256:

Error trapping: When an error occurs during execution of a statement, STSC's APL suspends processing at the point of error, retrieves the current contents of the special character vector ⎕*ELX* (error latent expression), and executes them as a line of APL. You might have previously set up ⎕*ELX* to force an exit from the executing function (returning some specific result indicating that a problem was encountered) or to generate a branch to a different part of the function, where the cause of the error may be determined by examining the system-generated variable ⎕*DM* (diagnostic message). If the program is sufficiently sophisticated, it may then be able to take corrective action and resume execution.

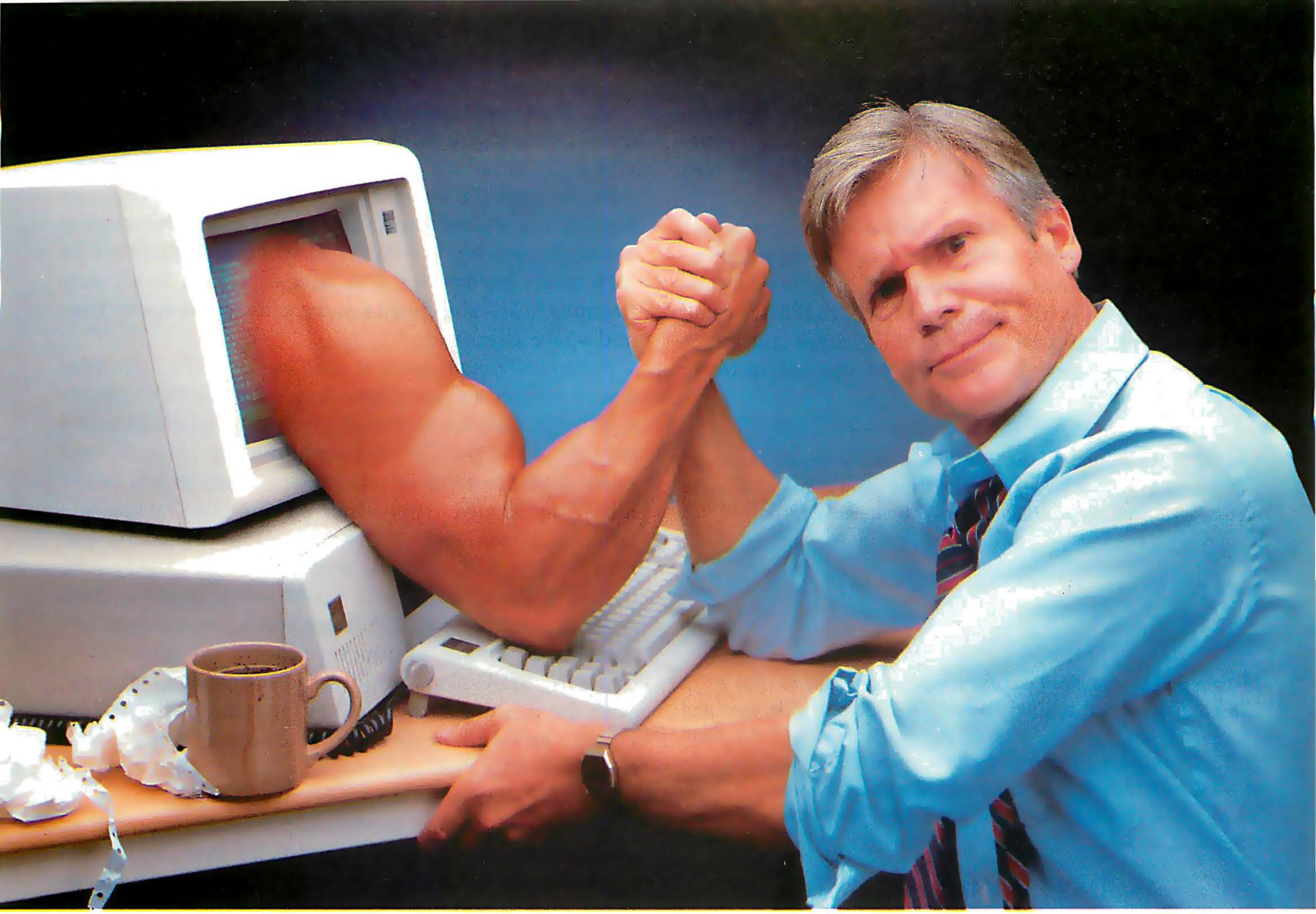
IBM's tool for the automatic handling of errors is the elegant system function ⎕*EA* (execute alternate). It takes two character-vector arguments representing APL expressions and attempts to execute the one on its right; if it fails because of an error, it goes back and executes the left argument instead. This allows you to exercise very fine control over errors occurring in different parts of a statement: for example, the expression in listing 5 adds the inverse of matrix A (or a matrix of 0s if A is not invertible) to the inverse of matrix B (or to a matrix of 1s if B is not invertible).

One problem with ⎕*EA*, however, is that if an error occurs in a defined function called from ⎕*EA*'s right argument, the execution state of that function is discarded before processing of ⎕*EA*'s left argument begins. This means that it becomes impossible to determine the cause of the error, to recover the values of the function's local variables, or to automatically resume execution at the point of error.

Disk file access: This topic brings up a long-standing philosophical debate between STSC and IBM on the subject of APL's control over its hardware environment (i.e., peripherals). STSC holds the view that APL should provide primitive system functions and variables that allow you to manage every aspect of your computer and has accordingly never been shy about adding such facilities to its APL interpreters. (APL*PLUS/PC boasts more than 100 system functions and variables as well as approximately 20 documented memory locations that you may modify to further control the system's behavior.) IBM, on the other hand, believes that such matters belong outside the realm of the APL language and should be handled by external programs (auxiliary processors) operating independently of the APL interpreter. You communicate your wishes to an auxiliary processor (and it in turn communicates results to you) by the clever device of sharing one or more variables in your workspace with the auxiliary processor: when you assign a value to a shared variable, the auxiliary processor can examine and modify it so that when you next look at the variable, it contains the result of your request. For example, a hypothetical clock/calendar auxiliary processor named AP24 (auxiliary processors are distinguished by number) might work as shown in listing 6.

The example demonstrates the use of the system function ⎕*SVO* to first "offer" to share VAR with AP24 and then to verify that the share was "accepted." If you want to program in assembly language, check out the IBM APL reference manual to find out how to create your own auxiliary processors to complement (or replace) the ones distributed with the system; this is potentially a very powerful capability.

Now, then, what about disk file access? Not surprisingly, STSC provides an abundance of excellent system functions to support two kinds of file organizations: the *APL component file*, a random-access arrangement of arbitrarily shaped APL arrays, and the so-called *native file*,



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which is simply a DOS file viewed as a long sequence of bytes that you can read or modify at will. The file functions are easy to use and extremely fast. You might especially enjoy the capability to snoop around DOS files interactively.

IBM, of course, provides a file auxiliary processor (named AP210) and a collection of APL-defined functions that use the auxiliary processor to achieve a pale imitation of STSC's file capabilities. AP210 illustrates all that goes wrong in practice with the elegant concept of auxiliary processors: it's difficult to use interactively because of the many steps involved in initiating and verifying shares, assigning data and hard-to-remember request codes to the shared variables, and retrieving data and success/failure codes from the shared variables. Also, because the auxiliary processor has no knowledge beyond the shared variables, it can't take advantage of available memory in your workspace and must use *its* own small buffers for disk access, which limits data transfers to 2K-byte chunks and creates unnecessary time and space overhead.

Printer and communication ports support: STSC provides a very powerful system function, called *⎕ARBIN*, that's somewhat tedious to use. It gives you detailed control over all of the parallel and serial ports in your PC and enables you to send or receive characters in any of the following modes: typewriter-pairing and bit-pairing APL/ASCII overlays (which enable communications with timesharing APL systems and with high-quality APL printers), 8-bit ASCII, and Epson dot-graphics (which enables printing of all 256 characters using the graphics features of Epson graphics printers). In addition to *⎕ARBIN*, STSC also supplies the *system terminal mode*; with the push of a function key, you can transform the PC into an excellent APL/ASCII terminal that emulates the Datamedia 1520 and enables you to switch between your APL workspace and a remote computer.

IBM provides more modest capabilities through two auxiliary processors. AP80 supports the first parallel port but will print APL characters only if your system has an IBM Graphics Printer (which, despite rumors to the contrary, is not quite compatible with Epson graphics printers); AP232 supports the first serial port and does a reasonably thorough job of it, although you would have to write a fairly sophisticated program to duplicate STSC's capability to make APL printouts with a serial printer. A set of APL functions furnished with the system uses AP232 to provide a very limited form of terminal simulation.

Full-screen I/O (input/output): STSC provides system functions that enable you to capture or modify characters and video attributes in any rectangular region of the screen. IBM's AP205 offers the same capabilities plus an excellent form-designing feature that should make it easy for you to support full-screen applications.

Machine language and memory access: In addition to vector-oriented versions of BASIC's PEEK and POKE functions, both APLs provide you with the capability to call machine-code subroutines stored in the workspace; in STSC's case, the code can be given access to APL objects and can modify them if necessary. IBM gives you the potentially powerful capability to write your own auxiliary processors.

Speaker support: A system function in STSC's APL allows you to generate a sequence of tones of specified frequency and duration. IBM offers a more sophisticated music-playing capability through auxiliary processor AP440 (similar to BASIC's PLAY statement).

Miscellaneous extensions: STSC's APL supports the *diamond* statement separator (which allows multiple APL

Listing 5: *An example of the IBM PC "execute alternate" function, which tries to evaluate the expression on the right and, if an error occurs, evaluates the alternate expression on the left.*

```
( '(⍴A)⍴0' ⎕EA '⍞A' ) + '(⍴B)⍴1' ⎕EA '⍞B'
```

Listing 6: *An example of auxiliary processors (APs) in IBM APL. Given a hypothetical auxiliary processor AP24 that gives time and date information, the name VAR is associated with AP24 (lines 1 and 2). This association is confirmed by the query in line 3 and the response in line 4. VAR then returns the time when passed the message 'TIME?' (lines 5, 6, and 7) and the date when passed the message 'DATE?' (lines 8, 9, and 10).*

```
      24 ⎕SVO 'VAR'
1
      ⎕SVO 'VAR'
2
      VAR←'TIME?'
      VAR
THE TIME IS 11:07:45
      VAR←'DATE?'
      VAR
THE DATE IS 12/01/83
```

Listing 7: *An example of the replicate extension to the compress (/) function. Normally, the compress function uses the left argument as a logical mask through which filter selected components of the right argument (see listing 7a). If the left argument contains numbers greater than 1, the corresponding element is repeated that many times in the result.*

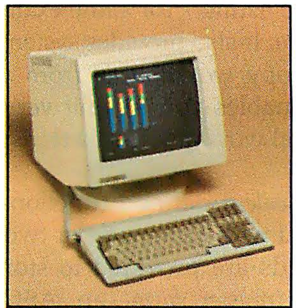
(7a)

```
      1 0 1 0 1 / 'ABCDE'
ACE
      0 1 1 1 0 / 'ABCDE'
BCD
```

(7b)

```
      0 0 3 0 0 / 'ABCDE'
CCC
      1 0 0 2 0 / 'ABCDE'
ADD
```

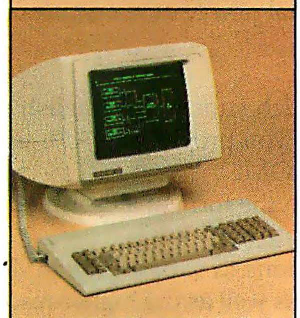
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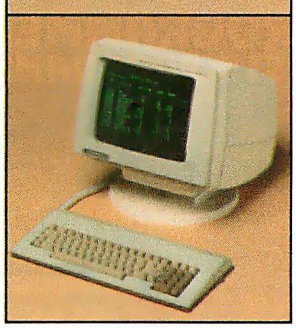
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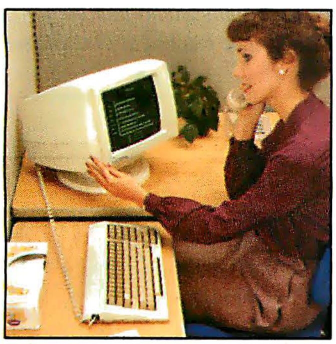


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IT ALL ADDS UP.

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statements on one line), the *replicate* extension to the compress (/) function (see listing 7 for some examples), and a *string search* primitive. It also provides system functions that can load or copy workspaces from within defined functions; this enables you to split very large applications among several workspaces in a transparent manner.

IBM's APL allows *ambivalent* defined functions (i.e., functions that can be used with either one or two arguments). System commands are provided to store and retrieve workspaces in *transfer form*, an ASCII-like representation of APL functions and variables that lets them be moved to or from other APL systems. (I used this feature to transfer the benchmarks from STSC's APL to IBM's through files created by the STSC native file facility.)

Both APLs allow you to sort character arrays by using dyadic forms of the grade primitive functions.

Planned extensions: Release 2 of STSC's APL*PLUS/PC (which will probably be available by the time you read this) promises to add several new features. Some of them are:

- APL keyword form, which substitutes English words for APL symbols and lets you program in APL without installing the character ROM
- on-line documentation in the form of a user-modifiable Help facility
- graphics primitive functions to support the IBM color/graphics display adapter (as well as the higher-resolution Hercules Graphics Card and possibly others)
- detached I/O, which enables input to the APL interpreter to come from a file and APL output to be redirected to a file
- the capability to execute DOS commands from within APL
- the capability to easily program the function keys

As for IBM's plans beyond version 1.00 of PC APL, your guess is as good as mine—IBM never announces its plans in advance.

Conclusions

After using the two packages, I feel that STSC's APL*PLUS/PC represents the more serious effort to provide a heavy-duty APL system that does not sacrifice control over any aspect of the IBM Personal Computer. I especially like its terminal mode and other communications features, file system (particularly the native file facility), flexible printer support, and clean integration of APL characters into the PC environment.

IBM's APL succeeds admirably in delivering the power of the raw APL language to the PC. It also makes a valiant effort to apply auxiliary processors to the task of controlling peripherals, but unfortunately it comes up short in this respect. The strengths of IBM's approach are that it provides a language uncluttered by special features, which makes it suitable for educational purposes (especially at its $195 price), and it gives an ambitious user the capability to customize the system by writing auxiliary processors. Unfortunately, the IBM APL's low price of $195 is offset by the major expense of installing an 8087 chip, which most people won't already have. ■

Jacques Bensimon has a master's degree in mathematics from New York University and works as a financial systems analyst for Becker Paribas Inc. in New York City. He can be reached at One Strawberry Hill, Stamford, CT 06902.

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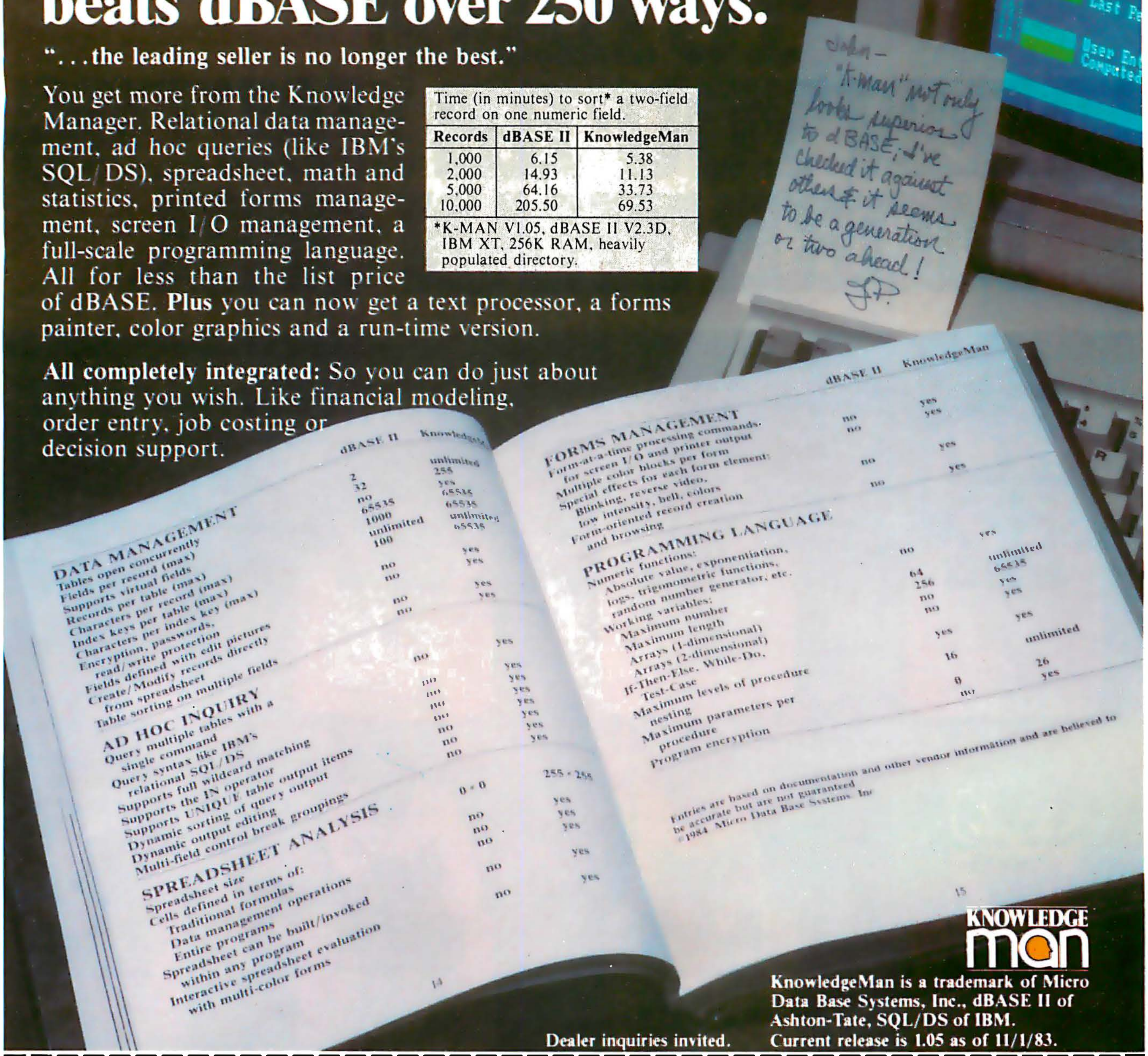
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Chalk Board's Powerpad and Leonardo's Library

A new large touch panel for the Atari 400/800, the Commodore 64, and the Apple II comes with a wide selection of software

by Elaine Holden

At last! Technology is finally beginning to incorporate educational philosophy. A new company, Chalk Board Inc., has come up with the Powerpad (hardware) and Leonardo's Library (software). The Powerpad, shown in photo 1, is a touch-sensitive pad that is used by the programs in Leonardo's Library as the primary input. The programs teach visual arts, music, mathematics, science, language arts, and social studies. However, only a fraction of the total series of educational packages is currently on the market.

The Powerpad does not involve traditional teaching approaches such as ditto sheets (those awful purple unreadables handed out by many teachers) and workbooks. Instead, there is direct interaction and immediate feedback with this teaching tool. This is referred to as the multimodal approach. In other words, if you touch it while you hear it and see it, you remember it longer.



Photo 1: *The Powerpad with the Mylar overlay for Micromaestro.*

Powerpad

The main component of the product is a 12-inch by 12-inch touch pad housed in a 20-inch by 17-inch hard plastic case. Mylar overlays that are part of the software package take the place of a conventional keyboard. Some areas of the pad are defined as keys, depending on the program. The flexibility of the Powerpad expands the range of potential users. Because an intricate keyboard is not involved, children and nontyping adults can learn with the computer in a much more relaxed and natural fashion.

The Powerpad connects through the game input port of your computer. It is lightweight, well constructed, and very versatile. [**Editor's Note:** *See the text box on page 270 for technical notes on the Powerpad.*]

Leonardo's Library

The set of learning packages is named after Leonardo da Vinci, who explored many areas of study. Similarly, Chalk Board's library tries to cover many disciplines in the Renaissance tradition. Each discipline has packages that range over five levels of sophistication and complexity. Almost any child or adult can locate a program at the appropriate educational level without becoming frustrated.

Included with each software package is a Mylar overlay sheet that fits over the active surface of the Powerpad. The overlay defines areas of the pad's surface that correspond with specific functions. The matching overlay imprinted with color-coded "buttons" serves as the menu and as special function keys.

For this review, I had access to three of the available packages from Leonardo's Library—Leo's 'Lectric Paintbrush, Micromaestro, and Powerpad Programming Kit. The first two packages help learners discover art and music; the third allows you to use the Powerpad as an input device in your own BASIC programs.

Leo's 'Lectric Paintbrush

Briefly, this program lets you finger-paint electronically. Using Leo's 'Lectric Paintbrush has to be the most fun I've had since I dipped my fingers into a paint dish as a six-year-old in Mrs. Sparrow's first-grade class.

Brush, paint, and crayons are often regarded as too messy for frequent use by children. Only when art class has begun or mother has the patience can a child paint. We tend to forget that a child's timetable may be different from ours, and later we are often disappointed when children do not develop enthusiasm for art.

With this program, you don't need paints or even paper. A stylus is provided, but I much preferred my fingers. The stylus, however, is useful for drawing fine lines. All you have to do is press the pad and the image appears on the screen.

The 36-page instruction booklet provided a very considerate walk-through of all the capabilities of the Paintbrush program, but it did not answer all my questions. It did, in fact, raise some of its own. These probing but nonthreatening questions provide directions for the learner without stifling the process of discovery. I had to experiment and explore to answer the questions.

Eight colors are provided for the palette. With the colors and my fingers, I was ready to create a masterpiece. Naturally, at first, I left small green fingerprints all over the place while trying to pinpoint where I left off. There's no way to tell on the Powerpad where I had already painted. The images show up only on the screen. Then I discovered that, much like my Logo program, the Powerpad has a Pen-up command that lets me see where my finger is without marking on the screen. When my finger is in the right place, I press the Pen-down area to recommence drawing.

First, I attempted to draw a landscape. Traditionally, a bright yellow sun hovers over all my versions of Mt. Monadnock. I used the Fill command to color in my sun. This is when I discovered that an incomplete circle (or any other shape, for that matter) will leak color all over the landscape. Cancel stopped the process and I cleaned up.

You can also move objects. The manual suggested making clouds. They fit in the picture, so I did. To and End commands define objects. I defined a cloud and used the Move command to put a second cloud, just like the first, in another place. Failing to recall the Pen-up command, I first positioned the cloud in the treetops. Even-



Photo 2: *A landscape created with Leo's 'Lectric Paintbrush.*

tually it made its way across the sky to the right position, then I cleaned up all my little fluffy fingerprints. The result is shown in photo 2.

You can get quite carried away with this and before long discover that all the computer's memory is used up. Economical use of computer memory is learned through trial and error at this stage but, to make it less frustrating, a Hashmark key (#) is provided on the Mylar overlay as well. When pressed, this key provides a vertical gauge of memory to the right of the picture. The artist can determine how much memory is left because, as he draws, this gauge fills with color.

Pictures can be saved; very clear directions are provided for this, with sample experiments. The experiments stimulate a learner rather than just provide him with lockstep directions. Too many programs give such precise directions that the student behaves like a robot. This is not teaching, this is programming.

Complete referencing is the form of an index is also provided. This is very useful for beginners. It is clearly organized and not complicated.

Micromaestro

This program is an answer to a music teacher's prayer. Limited funds prohibit quantity purchases of pianos, so classes often only hear music, but never make it. Prior solutions have included recorders for all (an agony of sound) and cardboard keyboards (no sounds but everyone got to practice).

Structured music class, individual classroom practice, and home use are all possibilities for Micromaestro, shown in photo 1. Naturally, this program is not a substitute for the real McCoy. I have yet to be convinced that any electronic marvel will ever take the place of a real piano. But basic music theory and composition can effectively be learned through this program. Its visual display function is especially useful, because it lets you see what you are playing on your computer screen. Photo 3 shows you what I mean.

Very little music theory is directly provided in the 40-page user's guide. I assume that this is because it is the most basic of the proposed five music packages and

At a Glance

Name
Powerpad, Leonardo's Library

Type
Hardware and accompanying Programming Kit;
Software: Micromaestro,
Leo's 'Lectric Paintbrush

Manufacturer
Chalk Board Inc.
3772 Pleasantdale Rd.
Atlanta, GA 30340
(800) 241-3989

Price
Powerpad, $99.95
Micromaestro, $24.95
Leo's 'Lectric Paintbrush, $24.95
Powerpad Programming Kit, $24.95
Other software in the Library will be available at prices ranging from $24.95 to $49.95

Format
Cartridge or disk

Documentation
36- to 40-page booklets plus self-explanatory keys on the Mylar overlays

Computer Needed
Commodore 64 and VIC-20, Atari, Apple, IBM PC

Audience
Preschool to adult

The Technical Side of Powerpad

The Powerpad contains an x,y matrix of 120 by 120 wires. The wires are connected to several 4051 eight-channel analog multiplexer/demultiplexers. The 4051s along one axis are connected to +5 volts. A 4024 seven-stage binary counter makes the 4051s transfer the +5 volts to its matrix wires, one wire at a time. When the user presses the Powerpad matrix, the wires under the point of pressure touch each other so that the potential from one axis is carried over to the wires of the other axis. When this happens, the scanning process stops and the SENSE line to the computer goes low. This alerts the computer that the Powerpad has been touched and the coordinates of the touched area may now be read. The coordinates are stored in two 4021 8-bit shift registers that, for programming purposes, are treated as one 16-bit register. The 16-bit register always contains the values present in the two 4024 binary counters. The x-axis coordinate is stored in the least significant 7 bits of the register, and the y-axis coordinate is stored in the next 7 bits. The most significant 2 bits of the register are always 01. These are discarded by the computer.

To read the coordinates, the computer pulses the CLOCK line to the Powerpad high 16 times. At each pulse, the shift register outputs one bit of its contents to the DATA line through a 4069 inverter. When all the data has been read, the computer pulses the CLEAR line to the Powerpad high. This tells the Powerpad to place the SENSE line low and continue scanning for a touch. Note that the binary counters are not set to zero. Instead, they retain their count and continue the scan from there.

The scanning begins from the point 0, 0. The y axis is scanned from 0 to 119 while x remains at zero; then x is incremented by one, and the y axis is scanned again.

By the way, the Powerpad uses the same I/O port on the Commodore 64 that the keyboard uses. This means that you cannot use the keyboard while the Powerpad is communicating with the computer, although Chalk Board Inc. says that it will tell you how to use both if you join the Padmasters Guild, the Powerpad users group.



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Photo 3: *A visual reproduction of music played with Micromaestro.*

also because the truly capable music student will attain a lot on his own.

The program carries the student along by suggesting various notes to play. Nothing much beyond this is suggested for songs, the remainder of the booklet being taken up with instructions on the use of various keys, symbols, and game suggestions. Hopefully, the remaining four packages in this series will teach some theory.

Powerpad Programming Kit

This programming kit consists of a blank overlay and a book that explains how to program the Powerpad with BASIC. This is not for the very young or the recent convert to the Computer Age. I was delighted with the program. Middle-school students who are familiar with computers and BASIC are naturals for this kit. I feel that average inquisitive elementary-age youngsters would have a problem, though, unless they are first instructed in the fundamentals of programming.

Conclusions

Leonardo's Library and the Powerpad are fine examples of educational tools. They follow sound educational philosophy, they stress creativity and problem solving, and they have the element of surprise. With these programs, students cannot rush through an exercise to get done, look at the back of the book for answers, or ask someone else—they must discover on their own.

The electronic wizardry of the Powerpad is impressive, and the rigid plastic housing keeps it quite safe. I would say it will last for a long time under normal use. The Mylar overlays also seem durable but, should accidents occur, they can be replaced for only $6.

In order for the student not to feel alone with his discoveries, another feature is the Padmasters Guild and the Chalk Board newsletter. The Guild membership is free to anyone owning a Programming Kit and costs $9.95 a year for everyone else. Included is a hot-line number for troubleshooting and publications on new programs for the Powerpad written by other programmers. The newsletter answers questions and publishes users' comments and ideas. These features, plus the excellent software, add up to a useful tool in education.■

Elaine Holden (22 Elm Street, Peterborough, NH 03458) is the supervisor of reading and language arts at the Merrimack School District in New Hampshire.

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Simulated Computer II

by Richard Grehan

Back in my college days, the only programming languages I had under my belt were BASIC and FORTRAN. I saw the computer as a mass of equipment so hopelessly complex that assembly-language programmers were like Nobel laureates. If you find yourself viewing the prospect of having to learn assembly language with the same pessimism that I felt back then, or if you just want to get a better idea of what goes on inside a computer, then Simulated Computer II deserves your attention.

Simulated Computer II from Carousel Software Inc. takes you on a fantastic voyage inside an imaginary computer. You can watch system registers being loaded, memory locations being modified, and even see and hear information flow from one location to another. Simulated I/O (input/output) devices allow you to load programs, execute them, and display their results. Also included are a programmable sound generator and a "turtle screen," a version of the line-drawing creature used with the popular Logo programming language.

Main Display

Nearly all of Simulated Computer II's action takes place on a single screen. It displays the four major components of the simulated computer (see photo 1). In the upper left is the *input device*, a stylized representation of a terminal complete with screen, keyboard, and a pair of tiny hands ready to begin typing. As you enter commands, the hands actually dip down to strike keys on the imaginary keyboard (a very nice touch that enhances the reality of the simulation; I give the designers an A+ for that one).

The upper-right portion of the display holds the computer's *output device*, where all program output and system error messages appear. This is a printer—obviously equipped with a tractor feed, since you can see the little holes in the paper—that makes a wonderful sputtering sound as its print mechanism operates.

The lower half of the screen displays the computer's *memory*, a whopping 24 memory locations arranged in a 4 by 6 matrix of boxes. The address of each box is easily identified by an attached tag, so there is no confusion about where things are coming from or going to. The last four locations have special functions with regard to sound and graphics, which I will describe in detail shortly.

The central processing unit sits in a sovereign position in the upper center of the screen. Six boxes inside the central processor represent its registers. Two of them, the accumulator and the program counter, are directly accessible by user programs. The other four—the instruction register, fetch register, increment register, and execute register—are used by the processor for its internal operation. The contents of these registers are visible at all times. (This simulated computer is a base-10 machine; registers and memory locations can hold numbers in the range +/−999. Having all operations performed in decimal numbers—rather than the expected binary or hexadecimal—is actually a good idea, since people trying to learn what goes on inside a computer have enough on their hands without having to worry about number base conversion.)

Connecting everything is the *system bus*, the real star of the show. Information traveling from one part of the computer to another is represented by a white, glowing electron that whizzes along the bus. This is the addicting part of the simulation. You find yourself entering and running programs just to watch the light show, and, best of all, you get to see exactly what's going on.

Simulated Computer II sports a pretty lean instruction set (see table 1). All mnemonics are three characters long, usually followed by a two-digit address. I believe that the designers were trying to find the balance between a product that was too simplistic and one that was too complex.

The two primary system commands are LOAD, which allows you to enter program and numeric data into memory; and RUN, which begins execution. Instructions may be loaded directly into memory in their mnemonic representation, but when RUN is executed, Simulated Computer's first action is to scan through all memory locations, translating all mnemonics to their operation code values so that all you see in the memory boxes are numbers. The subtle lesson being taught here, something that people familiar only with high-level languages are largely unaware of, is that data and instructions are indistinguishable until they reach the central processor.

Various versions of the RUN command let you execute programs at speeds from about 5 seconds per instruction up to a half-second per instruction or even single-step, which causes the system to wait for a keypress between each event.

Sound

Simulated Computer's sound capability is accessed by



Photo 1: *The Simulated Computer's main display, showing (clockwise from upper left) the input device (a terminal), the central processing unit, the output device (a printer), and system memory.*

storing a number into memory location 20. The number must be greater than 0 and less than 37 (less than 92 for the Commodore 64 version). These values seem to correspond to three octaves of an even-tempered scale starting one octave below middle C. However, I found it nearly impossible to determine the relationship of value stored to pitch produced since the generated sound is just a short beep. Even running the program at top speed, time between tones is nearly 6 seconds. Add to that the racket of the electrons racing from place to place as instructions are executed, and you can hang up the hope of generating even simple melodies.

Turtle Graphics

Memory locations 21, 22, and 23 control "a memory-mapped turtle." (For anyone not familiar with the turtle, it is the software incarnation of a small robot used to produce line graphics. You program the turtle to move along a path, and it leaves a "trail" on the screen as it carries out your commands.) Storing a number in location 21 tells the turtle which color to draw, location 22 determines the angle (in clockwise degrees) through which it will rotate before drawing, and location 23 selects the distance it will move. It is the act of storing a number in location 23 that actually sends the turtle on its way.

At a Glance

Name
Simulated Computer II

Type
Educational Simulation

Manufacturer
Carousel Software Inc.
877 Beacon St.
Boston, MA 02215
(617) 437-9419

Available From
Apex Resources Inc.
17 St. Mary's Court
Brookline, MA 02146
(617) 566-1569

Price
$29.95 suggested retail

Format
Cassette or disk

Language
Compiled FORTH (a FORTH interpreter is not required)

Computer
Atari series of microcomputers with 32K bytes of RAM or Commodore 64

Documentation
Approximately 35 pages

Audience
Anyone interested in learning the fundamentals of assembly-language programming (age range recommended by manufacturer: 12 to adult)

Mnemonic	Instruction Code	Description
LDA*xx*	1*xx*	load accumulator with contents of *xx*
STA*xx*	2*xx*	store contents of accumulator into *xx*
ADD*xx*	3*xx*	add contents of *xx* to value in the accumulator
SUB*xx*	4*xx*	subtract contents of *xx* from value in the accumulator
MUL*xx*	5*xx*	multiply accumulator by contents of *xx*
DIV*xx*	6*xx*	divide accumulator by contents of *xx* (results rounded to nearest one)
INP*xx*	7*xx*	input to location *xx*
OUT*xx*	8*xx*	output from location *xx*
JMP*xx*	9*xx*	unconditional jump to location *xx*
STP	000	stop
SKP*cc*	0*cc*	skip next instruction if condition *cc* is true; values for *cc*: 01 — accumulator < 0 02 — accumulator > 0 03 — accumulator = 0 04 — accumulator <= 0 05 — accumulator >= 0 06 — accumulator <> 0

Table 1: *Simulated Computer II instruction set. The variable xx represents a memory location and must be in the range 0 to 23.*

When the turtle receives a command, the main display disappears and is replaced by the *turtle screen* (see photo 2). This is an aerial view of the little fellow, surrounded by a rectangular border near the edges of the screen. As a program runs, the system flips back and forth between the main and turtle screens, and you can watch the graphics commands execute step by step.

I discovered that if you command the turtle to move some distance that would send it off screen, it rams into the border with a painful crashing sound and the program halts. I really wish the little printer had sputtered out ERROR-INJURED TURTLE.

A Sample Machine Cycle

Since the beauty of this simulation is its ability to reveal the individual actions that must take place for a single machine instruction to execute, let's take a look at what happens when we single-step through an LDA06 (load the accumulator from memory location 6). We'll assume that our instruction is stored at location 00:

1. The number 00 appears inside the program counter and fetch register boxes in the central processor. The numbers gleam brightly for an instant when they ap-

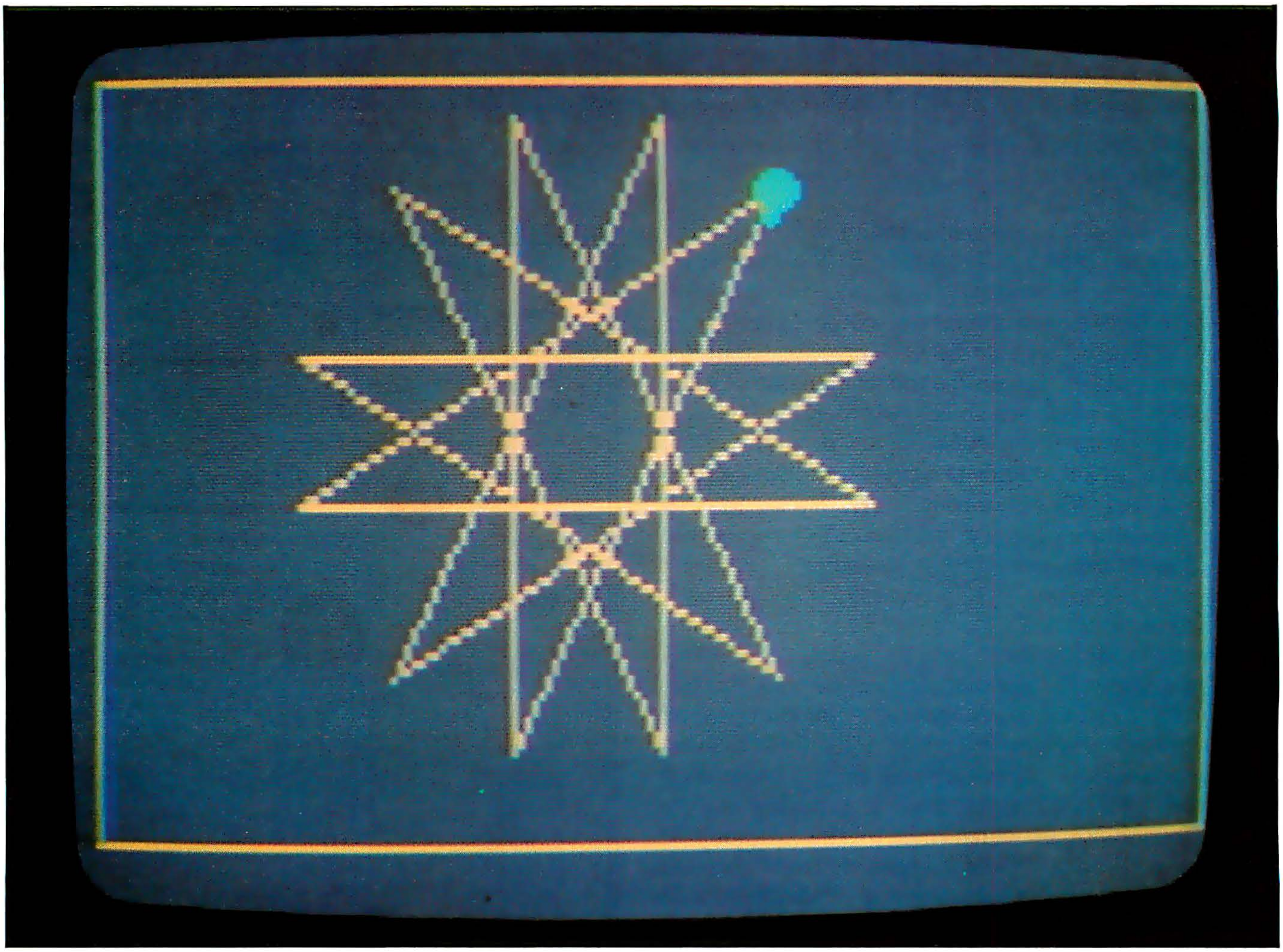
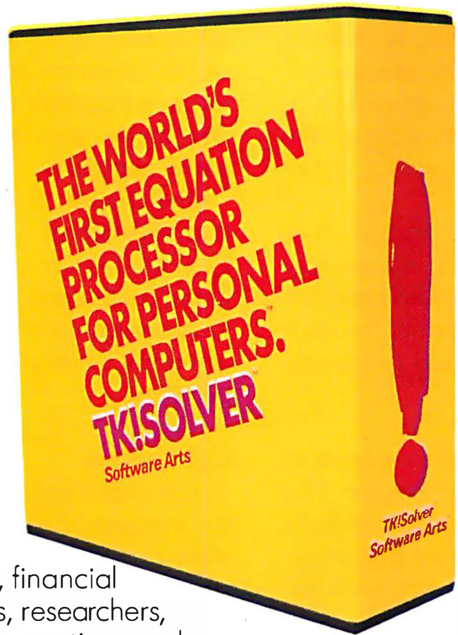


Photo 2: *Simulated Computer II's turtle hard at work on the turtle screen producing a 12-point star.*

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2. The contents of location 00 scintillate, and a buzzing electron zips out of that box and races over to the instruction register. There is another flash, and the number from address 00 appears; we've just witnessed a fetch from location 00. Meanwhile, the fetch register is cleared and the letters PC appear in the increment register. This means that the program counter is about to be incremented—an important action; most microprocessors set the program counter to point to the instruction following the one being executed.
3. The program counter flashes, and a 01 appears in it. The letters LDA pop up in the execute register. The computer has correctly decoded the contents of the instruction register.
4. The number in location 06 flares briefly, and another electron rushes out of that box, depositing the number in the accumulator. A 01 appears in the fetch register. Our load was successful, and the contents of the fetch register show that the computer is ready to execute the next instruction.

A rather drawn-out process just to get the contents of a memory location into the accumulator, I agree. The point is, that was a close approximation of what happens when a real computer executes a "load accumulator" instruction, and we were able to watch each individual step. This is what a graphic simulation is all about.

Documentation

At the time this article was being written, only a rough draft of the documentation was available. The final version should be a booklet about 35 pages long. In any case, the rough draft was extremely well written and easy to follow.

The first two chapters guide you through the process of loading Simulated Computer II on your computer, then describe the different elements of the display. This is followed by instructions for entering a number of example programs and a wonderful breakdown of central processor operations as you process a program in single-step mode (possibly the most worthwhile part of this entire simulation).

One chapter is devoted to sound generation—more than it deserves, I think—and one to turtle graphics. A lot is left to user innovation at this point. Several "program challenges" presented problems requiring programming solutions. I was pleased to find that sample solutions to these challenges were printed in the appendixes.

Conclusion

Although I agree with the designers' decision to keep the instruction set simple, I feel that their omission of indexed addressing and subroutine CALL/RETURN instructions was a mistake. It's easy to see from table 1 that Simulated Computer's instruction decoding scheme limits the number of processor instructions to 10, so that any additions would require a major overhaul of the entire product. However, given the importance of address indexing and subroutines, I urge the designers to include this in the next version of the program. Subroutines could be used to introduce users to the stack, which is also missing from the current design.

My other big objection concerns the sound generator. If there were some way to turn off the noise of the electrons and run the processor at twice its current top speed, maybe you could make a little melody or even a scale. As it stands, I don't see much use for this feature at all. Tom Smith of Carousel Software explained that, limited though it was, sound was found useful in motivating children who might not be attracted by other parts of the simulation. As he put it, "Different kids respond to different things."

Despite my complaints, I remain generally enthusiastic about Simulated Computer II. Introductory computer classes from high school up to continuing education should have something like this in their software libraries. I recommend it to anyone interested in learning more about what "goes on under the hood." Certainly programmers about to take their first jump into assembly or machine language will find it a worthwhile introduction to what lies ahead. I sure could have used it when I learned assembly language a few years ago. ■

Richard Grehan (621 North 100W. Apt. C., Orem, UT 84057) is an educational software applications programmer for WICAT Systems.

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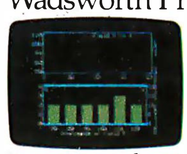
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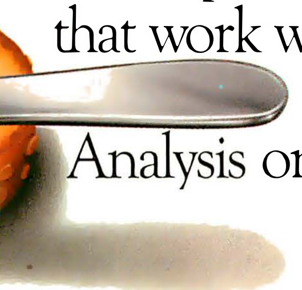
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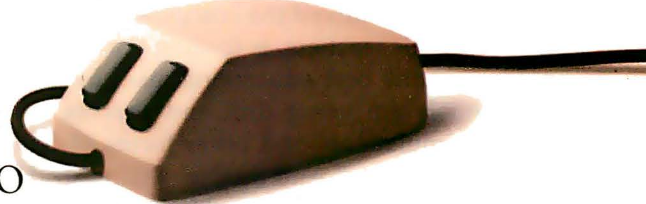
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Bank Street Writer

A word processor simple enough for children, but powerful enough for many writers

by Mario Pagnoni

"Word processing is the best invention since the erasable pen." With that perceptive comment, my 10-year-old son, James, thanked the computer industry. James, like many of his teachers, is finding that word processing is one of the best educational uses for computers. Sure, schools are using drill and practice programs, tutorials, simulations, and other forms of "computer-assisted instruction." And they're making strides teaching programming languages like BASIC, Logo, and PILOT. But through all the hoopla about the computer "saving" education, many teachers remain skeptical.

One thing that does impress many educators, though, is the machine's ability to help children express themselves. Children use word processing for a variety of writing tasks including stories, poetry, school reports, and letters to Grandma. James and his brother, Joseph (age seven), have used word processing for about a year. Their writing has improved and they enjoy it more.

For Joseph, word processing arrived just in time. Remembering his struggles with messy, erasure-riddled papers in our pre-word-processing days, he said, "The best thing is, when you erase your mistakes, the paper doesn't scrunch up and tear." Word processing bought time for his fine motor coordination to catch up to his expressive skills. And it's even more beneficial for those "special needs" children for whom the physical process of writing is difficult or impossible.

Everyone seems to agree that processing words is great for children. As they learn to manipulate text, they begin to look into the very fabric of writing. They become acutely aware of the effect of the different arrangements of their words. Moreover, they become conscious of the logical progression of thoughts expressed in good writing. Their writing gradually becomes clear and uncluttered.

Children today take to all phases of computing with little or no instruction. "It's the parents and teachers who need the handholding," said one computer instructor. "To get children writing, all you have to do is give them a word-processing package they can handle."

The problem is just that—finding a word-processing program that children can handle. Most are difficult to learn and even more difficult to use. And if, after mastering a program, the children don't run it for a while, they forget how to use it. Powerful editors with exotic functions bewilder children. Having to spend a long time learning a program frustrates them, and they may give up before doing any actual writing. Manuals are often confusing and intimidating. According to William Zinsser, author of *Writing with a Word Processor*, "If any single force is destined to impede man's mastery of the computer, it will be the manual that tries to teach him to master it."

One word-processing program that solves these problems and opens the world of processing words to children is Bank Street Writer by Broderbund Software Inc.

Bank Street Writer is a well-designed, inexpensive, easy-to-use word processor. It's not only simple for children to learn, it provides prompts to help them remember how to use it. Developed by the highly respected Bank Street College of Education to serve children, it is billed by Broderbund as "the home word processor." While it lacks the sophisticated features of a business word-processing package, it does everything most nonprofessional writers want. It's ideal for people with little or no computer experience.

Bank Street Writer consists of three programs—the writer itself, a tutorial (on the flip side of the disk), and the utility program (used to change how the writer communicates with your peripherals).

The Tutorial

Bank Street Writer features a logical, interactive tutorial containing five brief lessons. Working through the exercises (in less than 30 minutes) is all most children need to begin working with the writer program, and many don't need the tutorial at all. The same goes for the printed documentation. It is a concise, 28-page pocket-size manual with a useful index/glossary feature. It would be even more useful if you needed it more. The program is so simple and logical that you could misplace the manual after the first few days and never miss it.

At a Glance

Name
Bank Street Writer

Type
Word-processing program

Manufacturer
Broderbund Software Inc.
17 Paul Dr.
San Rafael, CA 94903
(415) 479-1170

School Package
(three copies of Bank Street Writer and teacher materials)
Scholastic Inc.
730 Broadway
New York, NY 10003

Format
5¼-inch disks with program on one side and tutorial on the other

Computers
Apple II Plus, IIe, Atari 400, 800, and 1200 with 48K bytes of memory and 1 drive, Commodore 64, IBM PC

Price
Home version: $69.95 (two copies and user's manual)
School version: $95 (three copies and teacher's manual)

Documentation
Broderbund version: 28-page pocket-size user's manual
Scholastic version: three-ring indexed binder

Comments
Simple enough for children and powerful enough for most adults

Audience
School age to adult

The Writer

Because the entire program loads into memory at the start, it is easy to use with just one disk drive. Boot the program disk, then replace it with a data disk. Boot time is quick—you'll be ready to write in about 12 seconds. There are no exotic graphics, just a blinking, beckoning cursor.

The writer program has three modes—Write mode (to enter text), Edit mode (to make corrections and revisions), and Transfer mode (to "communicate" with your drive or printer). You can get from one mode to another by hitting the Esc key. If you get confused, all you need do is press Esc until you come to a familiar mode. A message in the screen's upper-right corner always indicates which mode you are in.

Write mode gives you a 38-character screen that allows 18 lines of writing. A rectangle that resembles a sheet of paper outlines the screen; the area inside that border is for text. Outside the border, at the top of the screen, is an area devoted to prompts. This virtually eliminates the need to memorize commands. The few that you do need to know are logical: Control-I to indent 8, 16, 24, or 32 spaces; Control-C to center text; and Control-S to determine how much space is left in your file.

Bank Street Writer accommodates files of 1300 words if you have a 48K-byte machine—3200 words if you have an additional 16K-byte RAM (random-access read/write memory) card. To overcome these file-length limits you can create short files and then link them before printing. When text memory is almost filled, an additional prompt appears—"NOTE: ROOM FOR 50 WORDS REMAINING" (it counts every six characters as a word).

Bank Street Writer displays uppercase and lowercase letters on the Apple II without additional hardware. Hit Shift-N and the following letter will be capitalized. Hit Shift-N a second time for caps lock and once more to unlock the caps. If your machine has the Shift-key modification for capitalization, you can "notify" the Bank Street Writer through the Utility mode (this is unnecessary with the Apple IIe).

The program features word wrap so that carriage returns are necessary only to start a new paragraph. After 18 lines of text, the screen automatically scrolls up eight lines to allow for more typing. Characters can be erased in either direction with the left and right arrow keys.

In the Edit mode the cursor-movement keys (the four arrow keys on the Apple IIe, and I,J,K, and M on the Apple II Plus) are displayed in the prompt area. You'll have to "memorize" that B gets you to the beginning of your document, E to the end, U takes you up 12 lines, and D down 12 lines. To edit text, enter the Edit mode and use the cursor-control keys to locate your error. Then press Esc to get back to Write mode and type the correction.

Bank Street Writer "knows" whether it is booting on an Apple II Plus or IIe and loads the appropriate version. The IIe uses the open and closed apple keys to select a function and the II Plus uses the left and right arrow keys. In either case you access the function by highlighting your choice and pressing Return. Edit mode functions include Erase, Unerase, Move, Moveback, Find, Replace, and Transfer.

You can erase up to 15 lines of text at a time. To do this, select Erase from the prompt menu. Follow the step-by-step directions that tell you to place the cursor at the beginning of the text you want to erase—then hit Return. Place the cursor at the end of the text that you want erased—hit Return. The appropriate text will be highlighted and you will be asked, "Are you sure you want to erase highlighted text (Y/N)?" (Bank Street Writer always double-checks your command before executing it.) If, after erasing text, you decide that the erased portion should have stayed, you can Unerase (now there's a term children can understand). It could be the first example of "computerese" that *de*mystifies. If you have to learn to Access and Interface and Paginate, you may as well learn to Unerase.

The Move function is similar to Erase. You highlight the section of text you want to move (again, up to 15 lines) and indicate its destination. You are then asked, "Are you sure?" All of this is well prompted and, of course, you can Moveback if you change your mind. The Unerase and Moveback functions only allow you to undo

your last move *immediately after* that move. Thus, if you Erase a passage and then enter some new text, you will not be able to Unerase your original passage.

There are also powerful Find and Replace functions. Select Find on the edit menu. Type in the word or words (up to 29 characters) that you want to find. The first appearance of the word will be highlighted. Answer "Y"(es) to the prompts to find subsequent occurrences of the word(s). Replace operates in a similar way, replacing the word you searched for with the replacement of your choice.

Transfer mode (which you enter from Edit mode) is for disk and printer operations. It allows you to initialize disks, Save and Retrieve files, Rename or Delete files, Clear memory, Print-draft, Print-final, or Quit the writer program. If you attempt to Quit Bank Street Writer without saving your document, you will be reminded that "You did not save this text. Are you sure you want to quit now (Y/N)?"

The Print-draft function prints your text exactly as you see it on the screen (38 characters per line). This is useful for proofreading and leaves generous margins for teachers' comments. It also makes it easy for students to go back to the computer and find their mistakes on the screen. Some students "paste up" two print-drafts (side by side) to create a two-column effect for their school newspaper.

Print-final prompts you with options about how you want the printed document to look. You can select page numbering and double or triple spacing, for example. You can print copy that is 40 to 126 characters per line. Another useful feature allows you to see and adjust page breaks before printing. All of this formatting goes quickly, especially if you accept the default values by pressing Return after each question.

The Utility Program

You access the utility program by pressing Esc while Bank Street Writer is booting. It is used to list the names and passwords (used to lock files) of each file on your data disk, and to convert Bank Street Writer files (binary) to standard text files and vice versa. Conversions are slow. It took 15 minutes to convert this review (about 2600 words). You can also change default values like width of margins and page length through the utility program. In addition, the cursor can be changed from a blinking line to a white square, and you can engage a typing keyclick sound. The keyclick option is helpful to experienced typists who don't need to look at the keyboard or screen. Those barely audible clicks reassure them if they feel that they may have missed a key. I appreciated the keyclick option for a different reason. It reminded me that, although the program was designed for children, it is powerful enough for most adults.

Drawbacks

Bank Street Writer does not support right justification, tabbing, or embedding commands for things like underlining or boldface, though Broderbund does plan enhancements. Nor does it support split-screen operation, subscripts, or superscripts. These criticisms are almost invalid when you consider that the program was not designed for professional writers. This software isn't for formatters; it's for writers and would-be writers of all ages. My only complaints are that it's slow going from the Write mode to the Edit mode as text memory gets filled, and that there is no storage buffer that saves deleted text and lets you reinsert it elsewhere. Bank Street Writer supports all parallel and serial printers that are Apple compatible.

Conclusion

Bank Street Writer is great for school and the home, too. If you're planning to write the great American novel or do technical writing involving superscripts and indexes, look elsewhere. If, however, you want a program that your family can actually use the first day—a program that helps you recover from mistakes—then I recommend Bank Street Writer without reservation.■

Mario Pagnoni (76 Emsley Terrace, Methuen, MA 01844) is a teacher/freelance writer who spent last year teaching his children at home. He is working on a "how-to" book for home schoolers that emphasizes the use of microcomputers in education.

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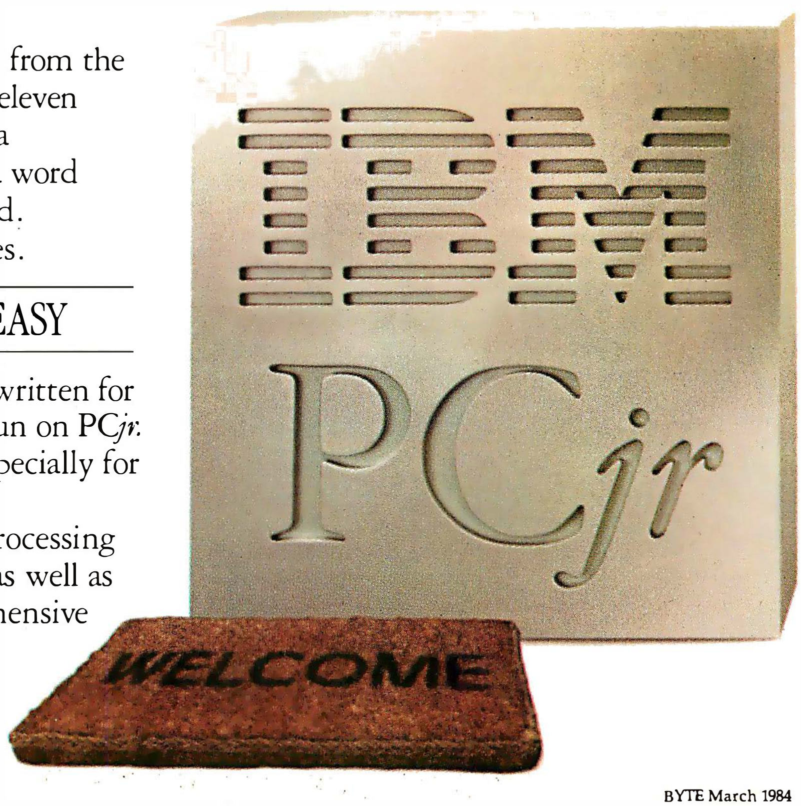
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SPOC
The Chess Master

by Emil Flock and Jonathan Silverman, Computer Hand Holding



Photo 1: *Screen generated by SPOC. The board is shown after move 8. . .QxP? in table 2.*

At a Glance

Name
SPOC The Chess Master, version 2.0

Type
Chess-playing program

Programmer
Jacques F. Middlecoff

Manufacturer
Cypress Software
1450 Koll Circle, Suite 108
San Jose, CA 95112
(800) 321-3900
(408) 995-5185

Price
$39.95

Format
5¼-inch floppy disk for IBM PC-DOS

Language
FORTRAN and assembly

Computer
IBM PC or XT; 128K bytes of RAM

Documentation
12 pages (5½ by 7 inches)

Audience
Chess players at all levels

Mean rating of USCF members (December 1983)	1537
E	0–1199
D	1200–1399
C	1400–1599
B	1600–1799
A	1800–1999
Expert	2000–2199
Master	2200–2399
Senior Master	above 2400
Highest active rating (Anatoly Karpov)	2710 (FIDE)
Highest rating ever (Bobby Fischer)	2760 (FIDE)
Belle's rating (approximate)	2203
SPOC's estimated rating	1700

Table 1: *Chess rankings for the United States Chess Federation (USCF) and Fédération Internationale pour le Développement des jeux d'Échecs (FIDE).*

The pleasure of playing chess on a microcomputer comes, in part, from the heartfelt appreciation of losing to a good opponent. You can replay the game from the printout, changing an occasional move and learning how to avoid specific problems. In addition, the computer never coughs while you're deep in thought and never blows smoke in your face, glares at you, or tries to confuse you.

If you like to recreate Bobby Fischer's prize-winning games, computer chess may not be for you. But if you want to practice with an opponent that puts up with untold verbal abuse and never gets tired, a chess program is the answer.

Few computers, and certainly no microcomputers, can seriously compete with a human chess master; however, computer chess programs can force the average person to play better chess. Lazy players who make blunders and initiate half-baked attacks usually lose badly to a program.

Computers—mainframes, minis, and micros—tend to play ugly, inelegant chess. They are impatient, which almost always leads to defeat against a master player. Robert Byrne, one of the best chess players in the United States, wrote that "computers lack positional judgment and do not know what to do in tranquil situations. However, tactically they are freer from error than the average human player."

Chess involves subtleties that are beyond everyday imagination. It is, indeed, an art form. You can lose a game completely and irretrievably by making a small error. A seemingly tiny positional disadvantage in the opening can lead to a devastating defeat by the middle of the game. "Endgame" study is an art form all its own. It's easy to lose early in the game to a world-class human chess player.

Mainframe and minicomputer chess programs are beginning to play well by any standards. A program called Belle achieved a master rating at 1983's United States Open against some top-notch human players (see table 1).

Computer Chess Theory

In 1949 Claude Shannon showed that a typical chess game contains some 10^{120} possible continuations. Today's "supercomputers" do 80,000,000 operations per second. Even a supercomputer would take 10^{110} seconds to run the entire chess tree. (Our universe is only 10^{17} seconds old.) The human player escapes this massive and impossible task by considering only a fraction of the moves available following any given move—and the machine must also. While the computer examines a vast number of continuations compared to the human player, that number is tiny compared to the total possible.

In chess the branching factor—the average number of possible moves from a given position—is 35. Therefore, a complete list of legal moves for a depth of three moves from any given position could contain 1.8 billion entries. To help prune this enormous tree, Belle uses an alpha-beta algorithm that throws away any move not better than the one already under consideration. Belle also remembers repeated positions.

Microcomputer Chess

The state-of-the-art chess programs for the IBM Personal Computer include two main contenders: SPOC (Selected Pruning Optimization Chess) and Bluebush (Bluebush Inc., 3379 St. Mary's Place, Santa Clara, CA 95051). These programs are new and haven't been thoroughly tested under tournament conditions. In this review we will concentrate on SPOC. After playing many

games to test its skill as an opponent, we've chosen SPOC's best effort to give you an idea of its quality of play (see the text box "Modern Benoni Defense" on this page).

For the average tournament chess player (who rates around 1500 on the United States Chess Federation's scale), SPOC is a worthy opponent. It plays at an average rating of about 1700 points, or as a "B" player (sometimes better, sometimes worse). SPOC has nine levels of play. When you give it three minutes to move (level 6), it plays like a strong amateur. We didn't try its "postal chess" mode (level 9, 60 minutes per move) because of the time involved to finish even one game. It played a number of fairly decent blitz games (level 2, 10 seconds per move).

Playing Against SPOC

You load SPOC by typing its name in at the PC DOS prompt. SPOC then asks you (1) to select the level of play (1-9), (2) if you want to print the moves, (3) if you have a color display, and (4) if you want to resume a previous game saved on disk. If you press F10 during the startup questions, it starts over and asks each question again, ignoring invalid answers.

You may choose to play either black or white. When you have chosen your color, the chessboard and playing pieces appear on the screen. If SPOC has white, it starts its own clock and begins "thinking" about its move. If SPOC has black, it starts your clock and waits for your move. At tournament level, the clocks accumulate time for a 40-move sequence, similar to a real tournament. For other levels, the clocks reset themselves after showing the accumulated time for each single move. (You will find you have a compelling desire to disconnect the loud beep that occurs each time SPOC makes a move.)

You move the chess pieces with the cursor keys. Position the cursor over the piece you want to move and press the carriage return. Next, position the cursor where you want to put the piece and enter another carriage return. SPOC doesn't follow the "if you touch it, you move it" rule. Until you press Return at a new square, you can retract your move.

SPOC checks the legality of all your attempted moves and growls at you if you try to castle out of check or move your King as if it were a Knight. (Castling is accomplished by moving your King two squares in the direction you wish to castle.) SPOC also handles "en passant" captures properly. [Editor's note: This is not always the case. I tested one version of SPOC and it did not execute an "en passant" capture correctly.]

Function keys let you change the level of play (F2) and save the game to disk (F1). To abandon the game and return to PC-DOS, press the Escape key (Esc). The SPOC version we tested lets you set up game positions with a stand-alone program on a separate disk. Just load the desired game position into SPOC and play.

How a Computer Plays Chess

How does a computer play chess? First, it generates a list of all its legal moves (the first ply) and all the legal responses to each of these (the second ply) as depicted in figure 1. This tree is extended, branch by branch (ply by ply), until the computer begins running out of time. Belle builds a tree of some 30 million positions, allowing a "look-ahead" of four moves (eight plies). SPOC

Modern Benoni Defense

White: SPOC The Chess Master, tournament level 6
Black: Jonathan Silverman, USCF Expert
San Francisco
October 2, 1983

SPOC's notation	Descriptive notation
1. d2-d4	1. P-Q4, N-KB3
2. g8-f6	
3. c2-c4	2. P-QB4, P-K3
4. e7-e6	
5. g1-f3	3. N-KB3, P-B4
6. c7-c5	
7. d4-d5	4. P-Q5, P×P
8. e6×d5	
9. c4×d5	5. P×P, P-Q3
10. d7-d6	
11. c1-f4	6. B-B4, P-QR3
12. a7-a6	
13. e2-e3?!	7. P-K3?!, P-QN4
14. b7-b5	
15. a2-a4	8. P-QR4, P-N5
16. b5-b4	
17. f1-c4	9. B-B4, QN-Q2
18. b8-d7	
19. e1-g1	10. castles, N-N3
20. d7-b6	
21. d1-d3!?	11. Q-Q3!?, P-N3
22. g7-g6	
23. e3-e4	12. P-K4, B-KN2
24. f8-g7	
25. c4-b3	13. B-QN3, P-QR4
26. a6-a5	
27. f1-e1	14. R-K1, castles
28. e8-g8	
29. b1-d2	15. QN-Q2, B-R3
30. c8-a6	
31. d2-c4	16. N-B4, N-R4
32. f6-h5	
33. f4-c1	17. B-B1, K-R1
34. g8-h8	
35. e1-d1?	18. R-Q1?, R-R2
36. a8-a7	
37. d3-e2?!	19. Q-K2?!, R-K2
38. a7-e7	
39. c1-g5	20. B-N5, P-B3
40. f7-f6	
41. g5-d2?	21. B-Q2?, N×QP
42. b6×d5	
43. b3-c2	22. B-B2, QR-K1
44. e7-e8	
45. g2-g3	23. P-KN3, P-B4

46. f6-f5	
47. e4-e5	24. P-K5, B×P
48. g7×e5	
49. d2-h6?	25. B-R6?, B-B5
50. e5-f4	
51. e2-f1	26. Q-B1, B×N
52. a6×c4	
53. f1×c4	27. Q×B, N-N3
54. d5-b6	
55. h6-g7	28. B-N7ch, K×B
56. h8×g7	
57. c4-a6	29. Q-R6, B-K4
58. f4-e5	
59. f3×e5	30. N×B, R×N
60. e8×e5	
61. a6-a7	31. Q-R7ch, R-K2
62. e5-e7	
63. a7×a5	32. Q×P, P-KB5
64. f5-f4	
65. g3-g4	33. P-N4, N-B3
66. h5-f6	
67. g4-g5	34. P-N5, N-K5
68. f6-e4	
69. c2×e4	35. B×N, R×B
70. e7×e4	
71. h2-h4	36. P-R4, P-B6
72. f4-f3	
73. a5-a7	37. Q-R7ch, R-B2
74. f8-f7	
75. a7-a6	38. Q-R6, R×P
76. e4×h4	
77. d1-d5	39. R-Q5, N×R
78. b6×d5	
79. a6×d6	40. Q×P, Q×Pch
80. d8×g5	
81. d6-g3	41. Q-N3, N-B5
82. d5-f4	
83. g3×g5	42. Q×Q, N-K7ch
84. f4-e2	
85. g1-f1	43. K-B1, R-R8ch
86. h4-h1	
87. g5-g1	44. Q-N1, R×Q mate
88. h1×g1	

In this game, SPOC holds its own at the beginning, then it makes the subtle mistake of developing a Bishop before a Knight, followed by an incorrect Queen posting. SPOC does come up with one move currently in vogue in master play—half move 8—a testament to its quality of play.

A few annotations on specific moves are in order here:

4. *Out of its own book openings, SPOC begins to "think" for itself and continues to make book moves (see reference 1).*
6. *A logical move, attacking the weak Queen pawn. However, white usually develops the Queen Knight first. This later becomes a problem.*
7. *In this opening, white customarily answers . . . a7-a6 (. . . P-QR3) with a2-a4 (P-QR4), to prevent black from expanding on the Queen side.*
8. *The idea chosen by SPOC of allowing . . . b7-b5 (. . . P-QN4) and then attacking the pawn chain has gotten some attention lately in master play. It's dubious here, though, because white will have trouble bringing his Queen Knight into play.*
9. *Defending the Queen pawn so the Knight can come to d2 (Q2). Again, white will have a pawn loose if 10. b1-d2 d7-b3 (N-Q2, N-N3).*
11. *Here the Queen controls three important squares: d5, c4, and e4 (Q5, QB4, and K4), permitting the Queen Knight to enter the game. But the Queen is also somewhat vulnerable on this square.*
13. *. . . White was threatening 14. a4-a5 (P-R5), winning the Queen pawn when the Knight retreats. Now black threatens 14 . . . c8-a6 (. . . B-QR3), skewering the Queen and Rook.*
16. *White has brought a Knight to c4 (QB4), an important objective in the Benoni defense. From here, the Knight attacks black's Queen and Queen Rook pawns, blockades his Queen Bishop pawn, and helps control e5 (K5). Unfortunately, the Knight is pinned, which points up the drawback of 11. d1-d3 (Q-Q3). In short, SPOC has played the opening logically, but not especially well. Black stands better and he now begins counterplay.*
17. *Defending the Queen Knight pawn, but now the Queen Rook is a shut-in. However, 17. f4-g5, f2-f6 18. g5-e3, f6-f5 or 18. g5-h4, h5-f4 (17. B-N5, P-B3 18. B-K3, P-B4 or 18. B-R4, N-B5) also favors black.*
17. *. . . This is partly to get the King off the white Bishop's diagonal in preparation for . . . f7-f5 (P-B4). But it is also a waiting move, because it is not obvious how white can improve his position. This tactic pays off, because SPOC now begins a series of weak moves.*
21. *A difficult move to understand, as it just gives up a pawn. After 21. g5-c1 (B-B1), though, black is ready to play 21 . . . f6-f5 (P-B4) with the variations 22. c1-g5, h5-f6 (22. B-N5, N-B3) or 22. f3-g5, f5×e4 23. g5-e6 [23. g5×e4, h5-f4 24. c1×f4, f8×f4 25. f2-f3, g7-d4 26. g1-h1, by×d5], e7-e6 24. d5×e6, d6-d5 (22. N-N5, P×P 23. N-K6 [23. N×KP, N-B5 24. B×N, R×B 25. P-B3, B-Q5ch 26. K-R1, N×QP], R×N 24. P×R, P-Q4, all in black's favor. The bottom line is: black's pieces are active; white's, passive.*
24. *If 24. d2-c1, d5-b6 (24. B-B1, N-N3), black wins.*
25. *Black loses a piece, but there is little hope.*

Of the rest, SPOC exhibits two flaws that are common to most chess programs (and many human players): a propensity for pointless checks and the inability to resign at an appropriate moment. The latter trait inspires black to sacrifice his Queen (on move 41) for mate.

typically looks at 500 positions (level 6) and looks ahead at least three plies (a move and a half). It goes further on those branches containing captures and checks.

The heart of the program is a scoring function. Each board position in the tree is scored by material, positional, strategic, and other criteria that are inserted as coefficients in this equation. Finally, the computer applies a "mini-max" selection technique to choose its own best (maximum) score and its opponent's best (the computer's minimum).

This whole scoring and mini-maxing process begins after the computer jumps out of its "book" (a predefined

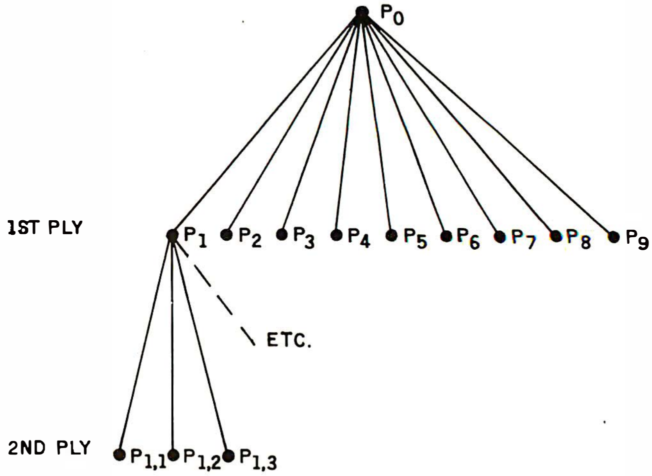


Figure 1: *A chess tree two plies deep.*

list of the program's favorite openings). The computer "memorizes" many openings in order to get past the critical first 8-12 moves, much as tournament players do. Belle's book contains 350,000 opening moves; SPOC's has about 3000. This means SPOC is forced out of book much earlier in a game than Belle.

Because SPOC only looks three plies deep, it relies on an extensive scoring function written in FORTRAN. A random-number generator prevents it from playing the same openings again and again. As it progresses to higher playing levels, SPOC restricts itself to its best openings. You can begin play at level 1 to get the widest choice of openings and then change to higher levels (F2) after a few moves. A handy move-immediate feature (F3) forces SPOC to make obvious moves like Queen recaptures.

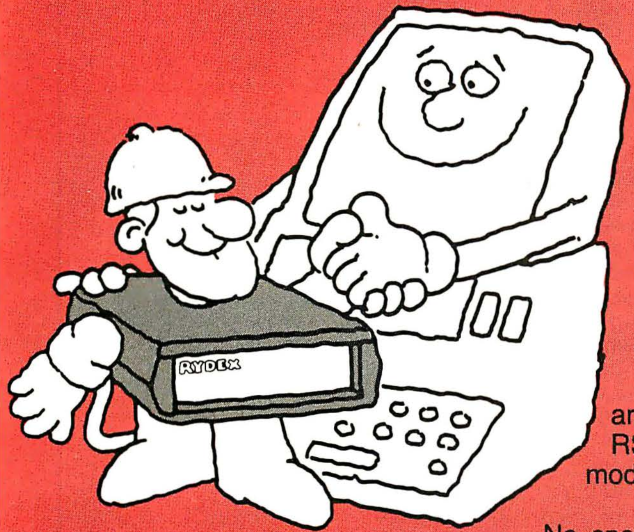
SPOC jumps into a separate endgame routine when it determines that there is not much power left on the board. In an endgame with no Queens, the King becomes a powerful piece. Before the endgame, SPOC's scoring function discourages King moves after castling. (You can't coax SPOC's King out from behind its protective wall of pawns.) Once the program decides that the endgame has started, however, it lets its King roam.

How to Beat SPOC

By examining the actual moves a computer makes, you can understand something about its scoring function. For example, if it makes useless checks, you can assume that the scoring coefficient for checking moves is too large. If it is slow to recognize sacrifices, perhaps the material coefficient is overriding the danger coefficients. It is difficult to work an instinct for the kill into the scoring function.

There are a number of ways to beat SPOC depending on your chess experience.

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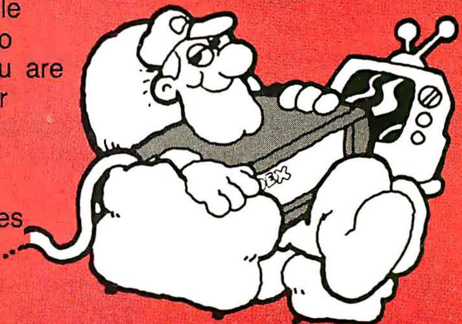


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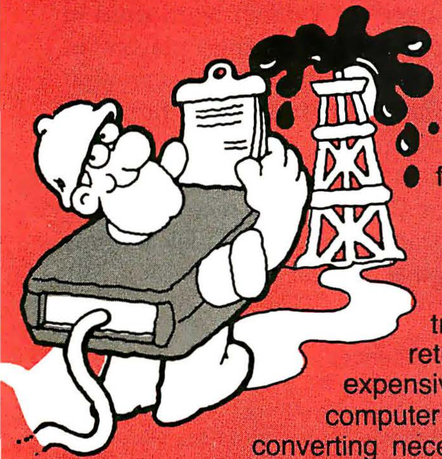
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1. Exploit its materialistic nature. Maintaining the balance of pieces is essential for SPOC; it's not likely to sacrifice material for positional advantage.
2. Take it out of its book early. If you don't, the middle game is sure to be a real fight. However, if you can play an opening SPOC doesn't "know," it starts its positional slide sooner.
3. Exploit its early Queen moves. This kind of mistake is a "natural" result of SPOC wanting to bring its heavy artillery to the front line. Chess "rules of thumb," such as "develop Knights before Bishops and minor pieces before major pieces," are hard to translate into a scoring equation.
4. Offer it "poisoned" pawns. Even the big machines have trouble here. Computer chess programs are "willing to give up too much for a pawn," says Belle's author, Ken Thompson.
5. Give it useless checks to make. SPOC will waste moves putting you in check because that's the first step to checkmate. These possibilities get good grades from the scoring function.
6. When all else fails—try speculative attacks on SPOC's King. Throw a few pieces at it. It never expects you to sacrifice.

The opening in table 2, ending in photo 1, shows you how to use the strategies above to defeat SPOC. An early stroll of its Queen leads to the capture of a poisoned pawn and then to the exchange of a pawn for a Knight.

Sicilian Defense
White: Jonathan Silverman, USCF Expert
Black: SPOC The Chess Master
October 3, 1983

SPOC's notation	Descriptive notation	
1. e2-e4	1. P-K4, P-QB4	
2. c7-c5		
3. b1-c3	2. N-QB3, N-QB3	
4. b8-c6		
5. g2-g3	3. P-KN3, P-KN3	
6. g7-g6		
7. f1-g2	4. B-N2, B-N2	
8. f8-g7		
9. d2-d3	5. P-Q3, P-Q3	
10. d7-d6		
11. g1-e2	6. KN-K2, P-K3	
12. e7-e6		
13. c1-e3	7. B-K3, Q-N3?!	SPOC moves its
14. d8-b6?!		Queen too soon.
15. e1-g1	8. castles, QxP?	A shameless grab
16. b6xb2		for which SPOC
17. a1-b1	9. R-N1, Q-R3	soon pays.
18. b2-a3		
19. c3-b5	10. N-N5, Q-R4	
20. a3-a5		
21. b5xd6	11. NxPch, K-K2	
22. e8-e7		
23. b1-b5	12. R-N5, QxP	
24. a5xa2		
25. e3xc5	13. BxP, B-Q2	
26. c8-d7		
27. f2-f4	14. P-B4, P-N3	
28. b7-b6		
29. d6-f5	15. N-B5ch, K-B3?	
30. e7-f6?		
31. e4-e5	16. P-K5ch, NxP	
32. c6xe5		
33. f4xe5	17. PxNch, . . .	A hopeless position
		for SPOC.

Table 2: *Chess moves used to defeat SPOC.*

Conclusion

While a Senior Master would be able to exploit SPOC's weaknesses, 90 percent of the estimated 40 million American players who "know" the moves would not. Even many tournament players would have trouble beating SPOC (the average ranking of the United States Chess Federation's 30,000 chess players is 1537).

Some informed people expect the programs to start beating the best of human chess masters. Professor Monroe Newborn of McGill University, who wrote Ostrich, predicts that a program good enough to be the world chess champion will be developed within two or three years.

David Levy, author of *All About Chess and Computers*, isn't so sure: ". . .the best chess programs see 10,000–50,000 times more (than humans) but do not understand what they see. . . . (This) produces a kind of monkey/typewriter situation. . . . (The computer) appears to play moderately well, whereas it is actually playing very weak chess so much of the time that its best results resemble the moves of strong players. Some programmers . . . argue that as the search becomes deeper, strategy and tactics merge into one. But in my opinion this view is erroneous."

David Slate, author of Northwestern University's Nuchess, has said that a chess program is ". . .like sharks swimming around, it's not very bright, but once it gets a taste of blood, it's right there and goes munch, munch, crunch."

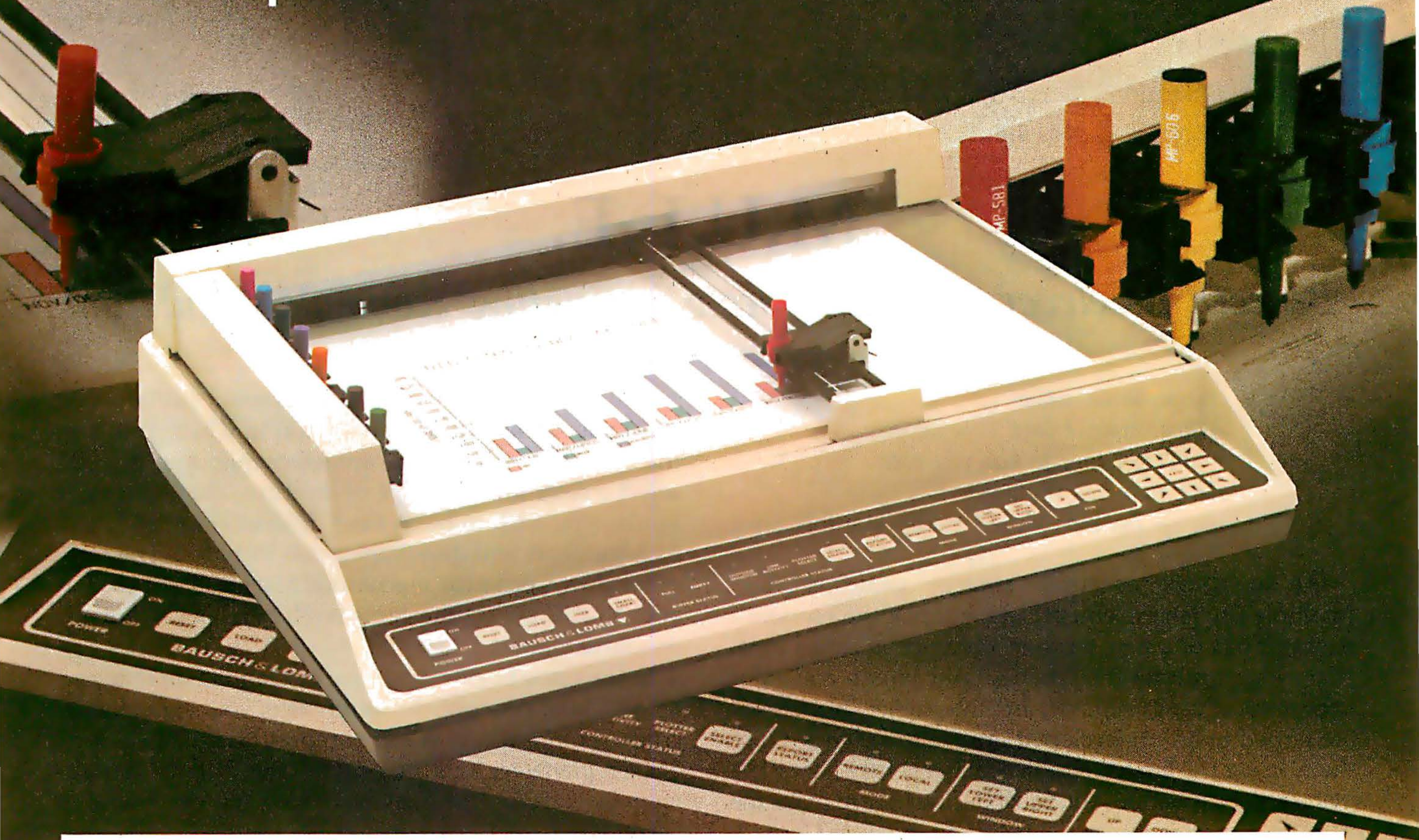
Whether you're a "patzer" (a Yiddish word used in chess lingo for "wood pushers" or inexpert players) or an expert, SPOC's utilitarian, methodical play can wear you out. We've had a great deal of fun with it, however; it has improved our play and our appreciation for the game. SPOC's ability to start a game from any board position and present it on the screen is a nice added feature. But the important thing is the level of play and that level is surprisingly high.■

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Emil Flock and Jonathan Silverman (Computer Hand Holding, 1800 Market St., #91, San Francisco, CA 94102) are both editors. Emil Flock is editor of Mentor, *the magazine on disk, and* The Reference Encyclopedia for the IBM PC. *He worked on the original version of Ostrich. Jonathan Silverman is a professional writer and editor, and an amateur chess player.*

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M.U.L.E.

Beneath its clever packaging lies a fascinating economic simulation

by Gene Smarte

Whoa, mule, whoa!
Whoa, mule, I say!
I ain't got time to kiss you now,
The mule has run away.
—"Buckin' Mule," traditional folk song

The fun-to-use economic strategy game M.U.L.E. (multiple-use labor element) lets you plot the economic development of a new territory on a planet called Irata. With your grubstake of money and goods and your knowledge of capitalism, you and three other "planeteers" are ferried to an undeveloped area of the planet. Once there, using the limited supplies of the general store, the planet's only structure, you must decide how to make the best use of your resources. Your supply ship won't be back for at least six months.

Before the game begins, the program introduction takes you through a demonstration in which you (and the computer, when there are fewer than four players) select a color and the type of creature—there are eight kinds—you wish to be. A brief description of each and its advantages and disadvantages is included. The computer always picks the mechanical Mechtron—but so can you. You also select the game level: beginner, standard, or tournament.

As the game begins, you have just landed on Irata and are watching your only link with help, your supply ship, cruise off into space. A status report lists the resources of each planeteer and the general store. (In the tournament-level game, the planeteers have but one round to become self-sufficient because their supplies are good for only one month.)



Photo 1: *After you've chosen the level of difficulty, picked the number of planeteers, and decided which of eight characters you'd like to be, the disk leaves the demo mode and loads the game. You'll see your spaceship pass over Irata, descend and deposit you and your fellow planeteers, and disappear from view.*

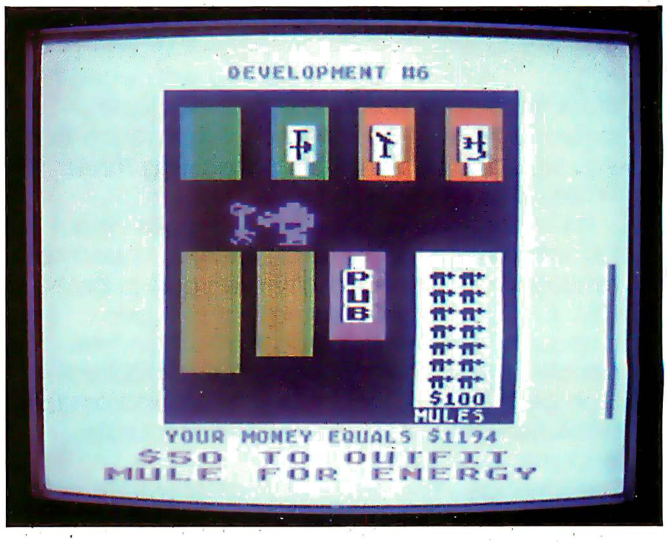


Photo 2: *Inside the general store. After selecting a plot of land, you pay your money, outfit a M.U.L.E. for your selected task, and head out to install the critter. The empty colored rectangles become additional choices as the difficulty of the game increases. The vertical bar at the right edge is a shrinking time indicator; when it's gone, your time is up.*

While "mule" might conjure up images of bearded prospectors and four-legged flop-eared beasts of burden, this M.U.L.E. is actually an intelligent (though sometimes unpredictable—it can run away) machine designed to resemble a real mule. You purchase it at the general store. Each M.U.L.E. must be outfitted for the task you choose: farming, energy production, or mining. Those are the main tasks of this game.

As in real societies, or "life in the rest of the galaxy," as mentioned in the player's guide, a balance must be struck between various needs and wants. In the case of Irata, you must have food, so farming is a requirement; you must have energy for the creation of all products, so energy production is necessary; and you must mine Smithore, the stuff from which a M.U.L.E. is made (except at the beginner's level), to ensure availability of the M.U.L.E. as the scope of Irata's development increases.

After the resource status report, the display shows an aerial view of the area of Irata to be developed. The landscape includes a fertile river valley ideal for farming, prairies for open-space energy production, and mountains for mining. A cursor scans the territory, and each planeteer chooses a plot of land by pressing a joystick push button. The color-coded plots correspond to the colors the planeteers select earlier in the game.

After the first round of plot selection, each planeteer has a limited time to enter the general store, decide which type of production best suits the plot just selected, outfit a M.U.L.E. accordingly, lead, via the joystick, the M.U.L.E. out to the plot, and install him (a M.U.L.E. is referred to in the masculine). Should you have some time left over, you can return to the pub in the general store and do a little gambling or go Wampus hunting. Gambling is an automatic way to win, but it ends your turn. The Wampus, as explained in the *Player's Guide*, lives in mountain caves, and when he opens his door a light flashes that signals his whereabouts. You must move quickly if you expect to capture him. He's difficult to catch, but he'll pay you to let him go.

When each planeteer has installed a M.U.L.E., production begins automatically. But, just as in real life, random events can help or (more likely) hinder your production. Planetquakes, meteor showers, and an imaginative array of pest attacks can wipe out a turn's production. These random events are particularly clever in concept and execution and had me looking forward to the next one.

After production, planeteer and store resources are displayed and an auction for each commodity begins. Here, a dog-eat-dog capitalist mentality can help. But you must remember that if, for example, all the planeteers try to corner the Smithore market and no one does any farming, you all have a good chance of perishing on Irata (shudder). I liked this touch of realism.

If you have the cash, you can buy what you want, and you can sell any surpluses, providing someone is interested. Both buying and selling prices are set by the planeteers with some limits in the beginner's level. The program sets the store's rate of exchange. With the conclusion of the auctions, an updated status report prepares you for the next round of plot selections as your first month of development ends. The game continues for 6 turns (beginner) or 12 turns (standard and tournament levels). At the conclusion, the player who has accumulated the highest net worth is the winner.

It's impossible to adequately describe all the interaction and economically realistic subtleties of M.U.L.E. The standard level increases the complexity of the beginner level with land auctions and selling, development-

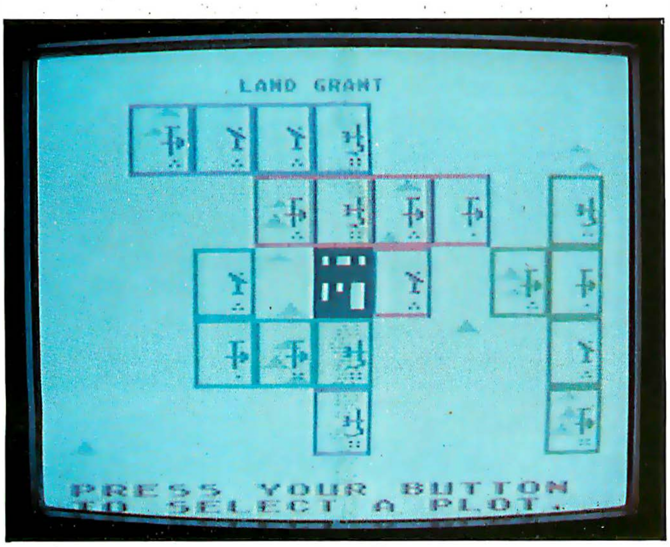


Photo 3: *After five rounds, Irata real estate is getting scarce. Colored squares identify players' plots. Symbols within each square indicate that a M.U.L.E. has been installed. The best food production is in the central river valley; energy gathering is best in the plains; the mountains are loaded with Smithore.*



Photo 4: *One of the three auctions that concludes each round. In this case, the seller has come down to $32 per unit; the buyers, however, are unimpressed as they are holding fast below the rock-bottom bid of $15.*


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At a Glance

Name
M.U.L.E.

Type
Economic strategy game

Manufacturer
Electronic Arts
2755 Campus Dr.
San Mateo, CA 94403
(415) 571-7171

Price
$40

Authors
Dan Bunten, Alan Watson, Jim Rushing, and Bill Bunten

Format
One 5¼-inch floppy disk

Language
Assembly language

Computers
Atari 400, 800 with 48K-byte RAM, Commodore 64

Documentation
6-page disk jacket, 20-page M.U.L.E. Player's Guide

Audience
Capitalists, entrepreneurs, and pioneers

strategy nuances, and gyrating resource prices. You can also sell below a "critical level" if you think that you can make it up later. The tournament level adds Crystite mining and Collusion (private trading between friends). Tournament play requires some fast thinking and razor-sharp business savvy because the time allowed for decisions is significantly shorter.

M.U.L.E.'s packaging and documentation make entertaining reading. In addition to providing an interesting description of the game's flow, the authors unveil their personal strategies. And the 20-page *M.U.L.E. Player's Guide* is peppered with playing tips along with the economic realities of pricing, economies of scale, the learning-curve theory of production, and the law of diminishing returns. This is definitely not a simplistic, learn it/be bored with it, kill-the-galactic-villains time-waster.

Conclusion

M.U.L.E. is an intriguing way to illustrate some of the triumphs and perils of free enterprise. While it falls in the broad category of games, it also offers an excellent means to test your business mettle. It's realistic, too, because just when you think you've done everything right, an unforeseen disaster can happen, like having your M.U.L.E. run away. ■

Gene Smarte is a BYTE technical editor. He can be reached at POB 372, Hancock, NH 03449.

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The Witness

A prose murder-mystery game for detectives whose business is trouble

by Dennis Barker

Somebody was nuts. I was nuts. Everybody was nuts. None of it fitted together worth a nickel . . . . I was in bad with the police, I had spent ten dollars of my twenty expense money, and I didn't have enough leverage anywhere to lift a dime off a cigar counter.

—Philip Marlowe, speaking in Trouble Is My Business *by Raymond Chandler*

I can understand Marlowe's lament now that I've played The Witness, the second prose murder-mystery game from Infocom. I logged a considerable number of hours trying to crack this programmed puzzler, but the case remains unsolved, wide open, no good leads, no evidence that sticks. This is one mystery-game review you can read without worrying about the solution being revealed.

Stu Galley, the author of The Witness, has styled his prose after that of Chandler, Ross Macdonald, and other captains of the hard-boiled mystery. Galley, a programmer at Infocom, has apparently read enough of the genre to emulate the style without mocking it. The descriptions are well done—quick but thorough and evocative. The narrative is detailed enough so that the player can imagine the surroundings but not have his mental picture cluttered with knickknacks. Because they provoke use of the imagination, the all-prose games are like the radio dramas of pretelevision days.

The story of The Witness begins: "Somewhere near Los Angeles. A cold Friday evening in February 1938." The player is the detective, dispatched by police chief Klutz to assist a nervous Mr. Linder, who says his life is being threatened by a somewhat sleazy Mr. Stiles. Linder's wife has recently killed herself. Stiles has allegedly been sending nasty notes.

A taxi drops you off at the Linder joint. The questions and decisions begin before you enter the house. Do you go to the front door? (Nah, too obvious.) Do you check out the garage? Do you stalk around the backyard? Remember, you have only 12 hours (720 moves) to solve the mystery, and every move kills a minute.

If you take the right steps, you can meet the main characters before they get away from the house. There's Freeman Linder, who's made millions in the Orient trade. There's his daughter Monica, a tough dame who acts "as though you were a masher who just gave her a whistle." There's Phong, the mysterious butler. And there's Stiles, who apparently was on very good terms with the late Mrs. Linder and allegedly wants Mr. Linder to join her in that Big Sleep.

The best detectives operate in a mode that balances logic and instinct. The Witness gives you plenty of opportunity to exercise both. You can minimize dead ends by keeping a list of questions asked and responses received. I sketched each room as it was described. Because the Linder house is big, I had to make lots of maps. However, the maps I drew were not much help. Despite an effort to diagram the layout of the place and to chart my steps, I frequently ran into walls and windows. This can be a problem when you're trying to shadow someone. At one point, I gave up mapping and relied on instinct, luck, and the handy LOOK AROUND command, which flashes a description of the surroundings on the screen. I have yet to determine if the trouble is due to a bug in the program or in the player.

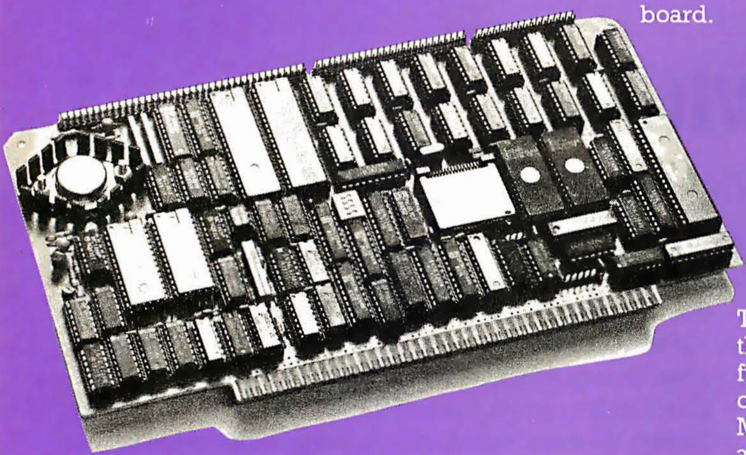
Infocom's parser, the program's language analyzer, is obviously a remarkable improvement on the simple two-word verb-noun commands of earlier adventure games. A player can interact with The Witness on a more articulate basis, which makes for a greater sense of realism. Despite this remarkable addition of adjectives, prepositions, indirect objects, and compound verbs, I still felt considerably limited in the vocabulary I could use. The rule book points out that the parser uses far more words than it understands, but when you're onto a hot lead, with clues and questions running through your mind, it's hard to remember that you're talking to a computer

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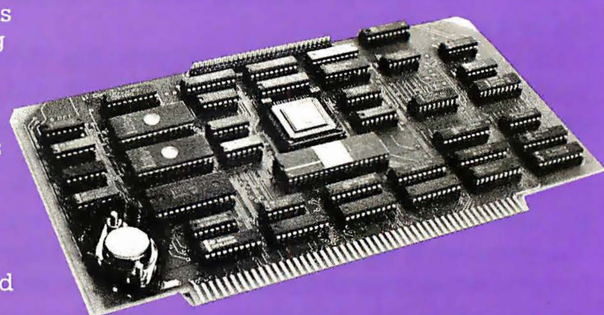
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program. Generally, the linguistic limitations cause only a minor inconvenience; you may have to rephrase a question until the parser understands. But in a few cases the restrictions impede the detective work. Here's a perfect example.

I asked one character to please tell me about Monica and her father. The program informed me that I couldn't use multiple indirect objects with the word "tell." This is an unfortunate snag. A detective dealing with several characters, particularly characters who are suspect, would want to know about the relationships between them. It's a line of questioning that can help reveal motives, and unearthing motives is what investigation is all about. Certain grammatical constructions are important to the detective of a programmed mystery.

The game's designers have provided some very helpful commands. The ones I used most frequently, besides the usual legwork commands (e.g., WALK WEST), were EXAMINE, which lets you look closely at something; ANALYZE, which includes checking for specific substances and fingerprinting; and SEARCH (something or someone), to which some characters do not react favorably. And as Holmes had his Watson, you have Sgt. Duffy, who can be called in for assistance. Duffy can handle analysis, booking, questioning, and other tasks—if you can find him. Failing that, you can still shout obscenities and even shoot at characters. (Galley anticipated certain input statements and apparently expected some players to get very frustrated.)

The Witness, in the Infocom tradition, is attractively packaged. The *National Detective Gazette*, the main piece of documentation, is cleverly and clearly written and features some nice illustrations. The graphic artists involved in this project deserve a round of applause. The reference card is straightforward and explains booting and playing procedures in terms simple enough to be followed by the village idiot. This is commendable.

Playing time varies greatly. Infocom games have reportedly taken from 20 to 60 hours (real time). You can play The Witness for five minutes if you like, store your game position, and resume the investigation later. If you arrest a character judged innocent by the grand jury (it takes a lot of evidence to convince the jurors), the session is ended for you. Wrong moves can be counted against you. Think before you act; think again before you enlist the steel.

Frustration is a part of this game. Questions multiply, answers are scarce. Hours after suspending play, you might find yourself evaluating a move you made or pondering that response a suspect made. How often have you played Monopoly and then wondered hours later why you didn't buy Baltic Avenue?

Remarkably, The Witness gives you an idea of the sort of situations an investigator is up against. Dropped into a situation in which a crime has been committed, you have to decide what questions to ask and whom to ask. You have to determine who's lying and who's got something to hide. You have to make assumptions about people you've only recently met. And your approach is based on scant clues: a note, a matchbook, a trace of gunpowder, a conflicting statement. Kojak never had it so rough. Of course, there is one big difference between being a detective and playing an adventure game. Real-life detectives sometimes must look down the barrel of a gun; the game player only has to look down the tube of a video display.

No law-abiding gumshoe likes a dead end, a lying suspect, or a stiff. But these are the elements of a good mystery and a good mystery game. Galley and the Infocom staff have succeeded in designing what Sherlock Holmes would call "a three-pipe problem."

At a Glance

Name
The Witness

Type
Prose murder-mystery game

Manufacturer
Infocom Inc.
55 Wheeler St.
Cambridge, MA 02138
(617) 492-1031

Author
Stu Galley

Price
$49.95; $59.95 for DEC RT-11, NEC APC, and CP/M versions

Format
5¼- or 8-inch floppy disk

Computer
Any of the following with 48K bytes of RAM, one disk drive, and a black-and-white or color monitor: Atari 400 or 800, Apple II, Commodore 64, DEC Rainbow or RT-11, IBM PC, NEC APC or PC-8000, Osborne, TRS-80 Models I or III, TI Professional, CP/M-based computers

Documentation
A computer reference card, National Detective Gazette, and assorted props (including a suicide note, a telegram, and a matchbook)

Audience
Game players

A Tip

If you begin to feel as if the district attorney is breathing down your neck, everyone's lying to you, and the Scotch is starting to taste sour, you probably need some help. An *Invisiclues* booklet contains some hints that might assist your investigation. It costs $7.95 and comes with a special pen that lets you reveal clues one at a time. To order, telephone (800) 262-6868; in New Jersey, (800) 238-2200. Above all, keep cool. And remember: it's Chinatown, Jake. ■

Dennis Barker is a copy editor at BYTE. He can be reached at POB 372, Hancock, NH 03449.



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The Tandy TRS-80 Model 2000

A Powerful New MS-DOS Machine

by Rich Malloy

You somehow knew that Radio Shack was eventually going to come out with an IBM PC-compatible computer, but the actual announcement was surprising nonetheless. Also surprising was the fact that Radio Shack chose not just to copy the IBM Personal Computer, but to design a much more powerful machine.

The Tandy TRS-80 Model 2000 has a number of notable features: a true 16-bit Intel 80186 microprocessor with a high clock speed, high-capacity floppy-disk drives, optional high-resolution color graphics, MS-DOS version 2.0, modest compatibility with the IBM PC, and a low price. To be sure, other machines boast such features, but this is the first to combine these features with a marketing structure as formidable as that of Radio Shack.

Physical Appearance

The 2000 departs radically from the traditional look of TRS-80 computers. The color scheme is the ubiquitous off-white. The keyboard is thin and light and has a very ergonomic look, and the monochrome monitor is small and stylish. Both are detached from the system unit, which resembles that of many other 16-bit computers.

Closely examined, the new model

has a number of interesting features. Most notable is the system unit's ability to rest horizontally on a desk or, like the DEC and Wang machines, vertically on the floor. And the computer's nameplate can be rotated 90 degrees to suit either orientation.

The nameplate itself is unusual: it reads "Tandy TRS-80 Model 2000." No Radio. No Shack. Apparently Radio Shack encountered some resistance to the word "Shack" on its high-end computers. The implication here is that, in the future, any new computer over $2000 will carry the Tandy label. Although Radio Shack denies the possibility, I wouldn't be surprised to find the Radio Shack Computer Centers renamed Tandy Computer Centers.

Immediately below the nameplate (or beside it, as the case may be) are two minor but important details: an easy-to-find power switch and a Reset button. For the benefit of those who abhor Reset buttons, the Control-Alternate-Delete key trio used by the IBM PC will also usually reset the machine.

At a Glance

Name
The Tandy TRS-80 Model 2000

Manufacturer
Radio Shack
1800 One Tandy Center
Fort Worth, TX 76102
(817) 390-3011

Processor
16-bit Intel 80186 at 8-MHz

Memory
128K to 768K bytes, with parity

Disk Storage
Two half-height, quad-density 5¼-inch floppy-disk drives (720K bytes each)
Alternate configuration: one 10-megabyte hard-disk drive plus one floppy-disk drive

Displays
Monochrome: 12-inch green display (80 by 25 characters) with optional two-color graphics (640 by 400 pixels)
Color: 14-inch RGB display (80 by 25 characters) with optional eight-color graphics. Sixteen possible colors to choose from

Keyboard
Detachable keyboard with 90 keys, standard typewriter layout, 12 function keys, numeric keypad, inverted-T cursor pad

Interfaces
One parallel and one serial interface

Expansion
Four expansion slots with nonstandard connectors

Software
Includes MS-DOS version 2.0 plus GW-BASIC

Compatibility
Can read 320K- and 360K-byte MS-DOS disks; can run some IBM PC software

Price
Basic system plus monochrome display: $2999
with color display and eight-color graphics: $4197
Hard-disk system plus monochrome display: $4499

The Displays

Radio Shack offers a choice of two displays: a small green monochrome monitor for $250 and a large color RGB (red-green-blue) monitor for $799. A two-color graphics option is available for both monitors for an additional $449. Extra memory chips for eight-color graphics on the color monitor sell for $199. In addition, a small pedestal base is available for the monochrome monitor for $90.

The monochrome monitor has a 25-MHz bandwidth without interlacing. The characters are sharp and steady: the character font is simple and readable, although not as ornate as the IBM PC's monochrome monitor. If you desire, you can replace the entire 256-character set with your own character set. Characters can also be displayed in either double-width or double-height sizes.

The color monitor uses the same character generator as the monochrome monitor. The characters are well formed and readable in most colors.

The graphics resolution of both monitors is an impressive 640 by 400 pixels (picture elements). When the eight-color graphics option is installed, eight out of a possible sixteen colors can be displayed at once. (These colors are the standard white, black, red, green, blue, magenta, cyan, and yellow, with each color available in both high and low intensity.) Color-mapping hardware allows you to change colors quickly on the screen.

Seeing a display of color graphics on a Radio Shack business computer is somewhat unusual. More unusual, however, is the speed with which the graphic images are drawn. Thanks to a faster microprocessor, the Model 2000 can draw charts and graphs in what seems to be less than half the time required by the IBM PC.

The Model 2000 reportedly has smooth-scrolling capability (i.e., it can scroll pixel by pixel rather than line by line), but I did not see this demonstrated. The scrolling I *did* see was very fast.

The Keyboard

The keyboard on the 2000 has a very nice touch and is one of the finer keyboards available. It lacks the peculiarities that have plagued other computers and previous Radio Shack designs. The typewriter keys appear in a standard IBM Selectric typewriter configuration. Cursor keys are in an inverted T, just to the right of the typewriter keys, and a numeric keypad is placed to the right of the cursor keys. A row of twelve function keys is arranged in groups of four and runs along the top of the keyboard. This logical arrangement makes it easy to find a particular function key.

The Insides

Tandy has decided to use Intel's powerful but infamous 80186 microprocessor chip, which is similar to Intel's 8086 chip except that it incorporates several necessary support functions directly into the central processing unit (CPU). These functions include a clock-pulse generator and two high-speed direct-memory-access (DMA) controllers. The true 16-bit processing power of the 80186 gives it about a 40 percent speed advantage over the 8088, and the 8-MHz clock speed of Tandy's 80186 chip

gives it another 40 percent advantage over the IBM PC's chip. Additionally, the 80186 has a dedicated adder circuit for very quick memory-address calculations. The result, claims Radio Shack, is a program execution time three to six times faster than the 4.77-MHz 8088. We did some informal tests with Multiplan and were impressed not only with the processing speed, but also with the disk-access speed.

The 80186 has been chosen by several system designers because of its speed and high level of integration (see "The Pronto Series 16," June 1983 BYTE, page 168). Unfortunately, Intel reportedly had to redesign parts of the chip and is several months behind in its shipping schedule. A number of systems are waiting for the chip, and even Tandy may have problems getting it. As of this writing, the Model 2000 has not yet appeared in large numbers. But if anyone has enough clout to get the chip, it's Radio Shack.

The Tandy 2000 also has a socket for the 80187 floating-point numeric processor. Radio Shack isn't saying much about this capability, and it might be awhile before this chip is available, but when it is, this machine should be a devastating number cruncher.

As for memory, the Model 2000 comes with a minimum of 128K bytes. An additional 128K bytes can be placed on the motherboard, but beyond that you will have to add expansion boards populated with either 128K or 256K bytes. The upper memory limit is 768K bytes.

Disk Storage

One of the problems with a faster microprocessor is that floppy disks tend to fill up faster. Radio Shack has more than compensated for this less-than-major difficulty. The Model 2000 uses quad-density disks, with each disk holding 720K bytes of data—twice that of the 360K limit of the double-sided IBM PC disks under PC-DOS version 2.0.

Interfaces

The Model 2000 comes with both a Centronics parallel printer port and an RS-232C serial port. An optional

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board allows you to interface the 2000 with a standard television and a joystick. Another optional board lets you interface with a mouse. This board also includes a clock and the MS-Windows operating environment.

Expansion Capabilities

The Model 2000 has four horizontal expansion slots accessible from the rear panel. Expansion boards are slipped in like trays. Each board has a nonstandard connector that consists of three rows of about 30 pins (see table 1 for a list of expansion boards available for the Model 2000).

The Model 2000 can also be purchased with a 10-megabyte hard-disk drive instead of one of the floppy drives. This configuration costs $4250 without a monitor. Since the hard-disk drive sits to the left of the floppy-disk-drive enclosure, a second floppy-disk drive can still be added. Radio Shack has not yet made this second drive option available.

Software

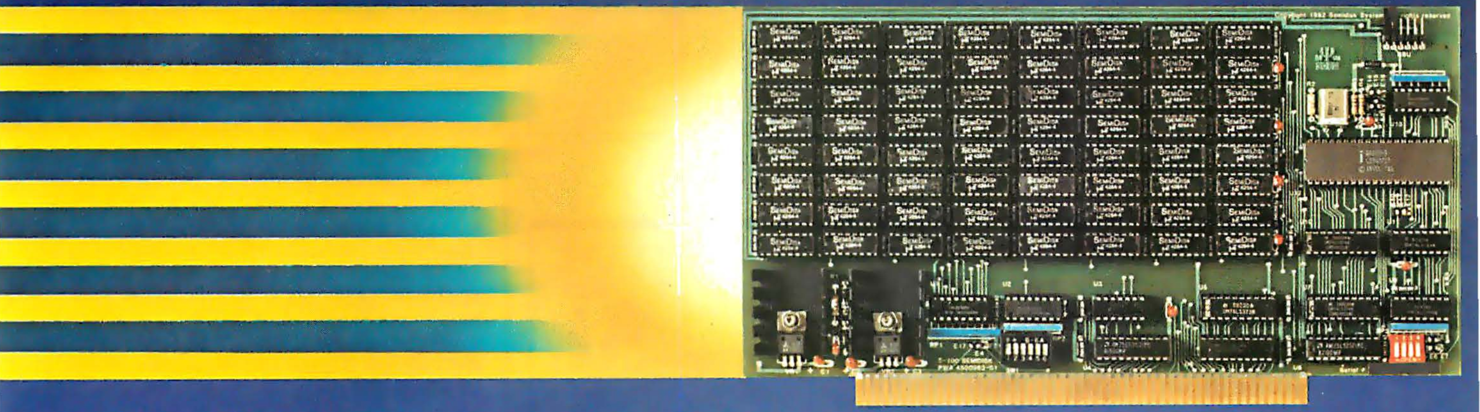
Of course, the most important part of any new machine is its software. Radio Shack's last 16-bit computer, the 68000-based Model 16, was hampered for a while by the lack of 16-bit software. The Model 2000, with its popular MS-DOS operating system, should have a much easier time.

The standard system comes complete with MS-DOS version 2.0 and Microsoft's GW-BASIC interpreter. In addition, Radio Shack offers many software package options (see table 2). More packages should be available in the future, but don't expect your local Radio Shack store to carry a huge assortment of MS-DOS software—these stores already stock a wide assortment for the other TRS-80 machines, and Radio Shack says that it does not want to overburden its dealers.

As you can see from table 2, Radio Shack offers at least one example from each of the main categories of applications software. You can be fairly sure that all major MS-DOS software houses will supply configurator programs that allow you to configure their software for the Model 2000.

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128K-byte memory board	$499
256K-byte memory board	$798
Other options	
Monochrome monitor	$249
Color monitor	$799
Second 128K-bytes memory	$299
Digi-Mouse	$100
Floor stand	$145
Monochrome display pedestal	$ 90

Table 1: *Expansion boards and options for the Model 2000.*

Software	Type	Price
Planetfall	Game	$ 50
Videotex Plus	Communications	$ 50
Witness	Game	$ 50
MS-Assembler	Macro assembler	$100
Home Account. Plus	Personal finance	$125
PFS:Report	Report generator	$125
PFS:Write	Word processing	$140
PFS:File	Database	$140
PFS:Graph	Business graphics	$140
Multiplan	Spreadsheet	$249
Multimate	Word processing	$250
GW-BASIC compiler	BASIC compiler	$300
MS-Pascal compiler	Pascal compiler	$300
MS-FORTRAN	FORTRAN compiler	$350
MAI/Basic Four	Purchase orders	$395
	Accounts payable	$495
	Accounts receivable	$495
	General ledger	$495
	Inventory control	$495
	Payroll	$495
COBOL	RM-COBOL compiler	$595
dBASE II	Database	$595

Table 2: *Software offered by Radio Shack for the Model 2000.*

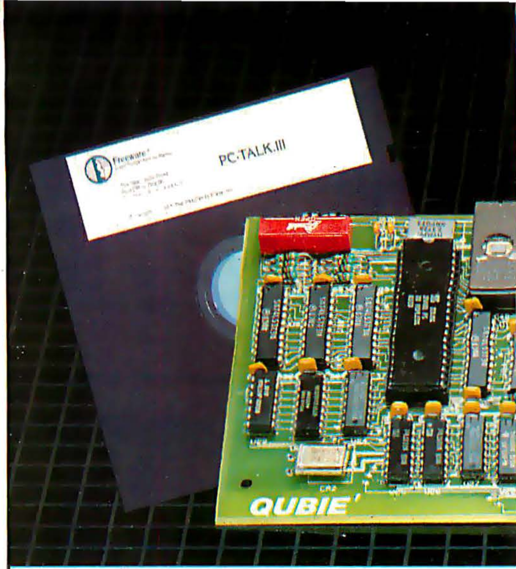
2000's BASIC interpreter is its graphics capabilities. Because of the Model 2000's fast processor, its version of BASIC runs rings around that of the IBM PC. To see the FILL routine in action is especially impressive.

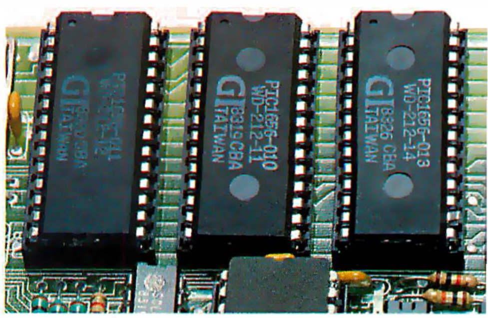
Watch for one particular software package for this machine. Ovation, which should be available during the second quarter of 1984, lets you go from spreadsheet to word processor to database manager very easily without having to cut and paste to transfer data. Demonstrations of Ovation at COMDEX in November left no doubt that applications software has advanced to a new level.

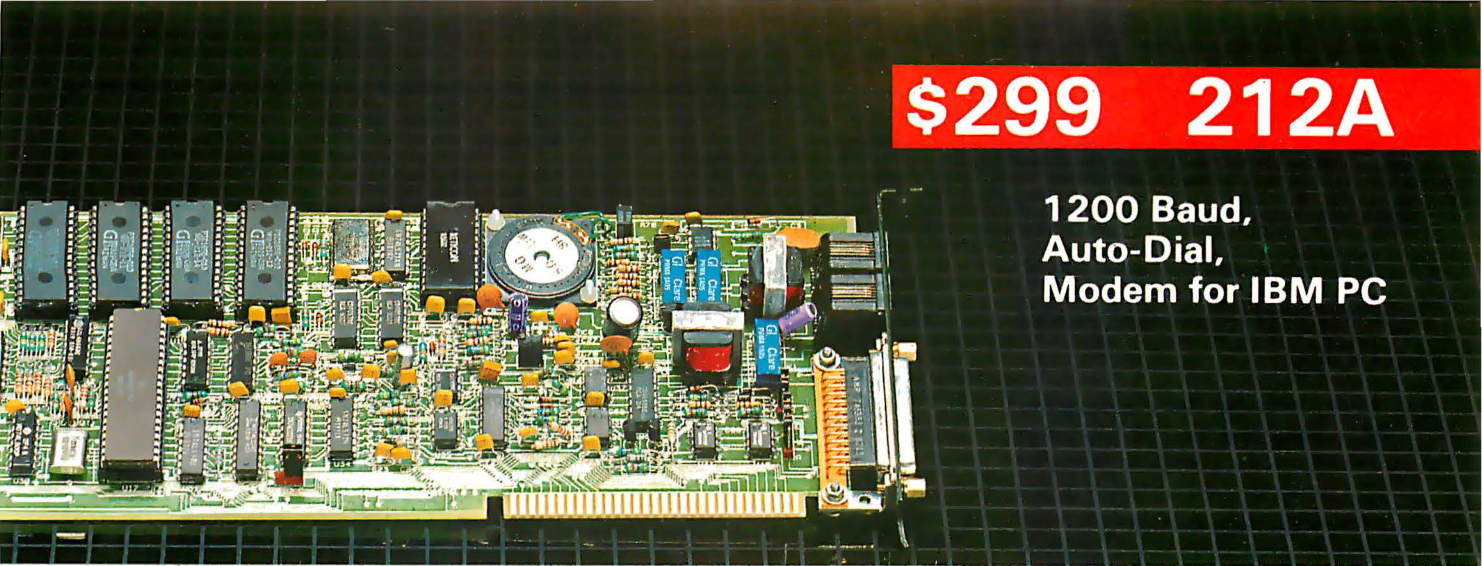
As for that other operating system, CP/M-86, Radio Shack has expressed no interest in making a second operating system available for the Model 2000.

Compatibility

Radio Shack stresses that its machine is an MS-DOS machine, *not* an IBM PC clone. Yet in its advertising, Radio Shack repeatedly makes direct comparisons with the machine from Boca Raton. And obviously, compatibility with the IBM PC is important because of IBM's ever-growing library of software. To its credit, Radio Shack makes it quite







PC 212A/1200:

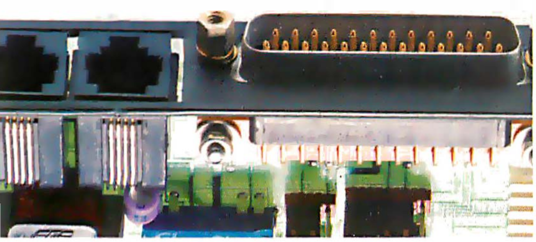
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ADVANTAGE #2

Optional external serial port connector



AN ASYCHRONOUS ADVANTAGE



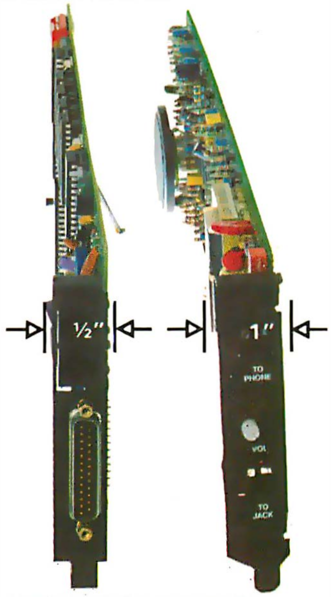
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Circle 302 on inquiry card.

Software	Publisher	Runs on Model 2000?
1-2-3	Lotus Development	No
Accounting	IUS	Yes
Accounting	Open Systems	Yes
Bottom Line Strategist	Ashton-Tate	Yes
DJ Market Analyzer	Dow Jones	No
Easywriter	IUS	No
Peachtext	IBM	No
Planfin	Business Software	Yes
Quickcode	Fox & Geller	Yes
Random House Dictionary	Aspen/Wang	Yes
Smartcom	Hayes	No
Spellguard	Sorcim	Yes
Supercalc2	Sorcim	No
Superwriter	Sorcim	No
Tax Preparer	Howardsoft	Yes
The Word Plus	Oasis	Yes
Visicalc	Visicorp	No
Volkswriter	Lifetree	No
Wordplus/The Boss	Professional Software	No
Wordstar	Micropro	No

Table 3: *Partial list, compiled by Radio Shack, of popular MS-DOS software, indicating which packages will run on the Model 2000. For more information, check your local Radio Shack dealer.*

clear that several IBM PC programs will not run on the 2000.

In brief, any IBM PC program that, for the sake of speed, bypasses MS-DOS routines and directly accesses the IBM's memory is unlikely to run on the 2000. Similarly, any program that makes use of certain unique keys on the IBM keyboard or the unique graphics features is also unlikely to run (see table 3 for a list provided by Radio Shack of those programs that will or will not run).

In some cases, the obstacle to running a particular program is trivial. For example, Radio Shack mentioned a program that accesses a certain memory location in the IBM PC to ascertain whether a monochrome or color monitor is being used. To make this program run on the 2000, you simply change two bytes in the program so that it accesses the equivalent memory address on the 2000.

Obviously, some programs are more difficult than others to "port" to the 2000. Note that the best-selling 1-2-3 package from Lotus Development is not among those offered by Radio Shack. This may reflect Tandy's preference for Ovation as much as the difficulty of porting 1-2-3.

Two additional levels of compatibility with the IBM PC require mention. The first is disk compatibility and the second is hardware compatibility.

Radio Shack makes it quite clear that several IBM PC programs will not run on the 2000.

With regard to disks, the 2000, because it uses a quad-density disk format, has sacrificed complete compatibility with the IBM. The 2000 can read an IBM disk but it cannot write to one, and, while this situation is better than nothing, I'm sure that the limitation will be more than a little frustrating. (I should note that the 2000 did have trouble reading one of my IBM PC disks.)

As for hardware compatibility with the IBM PC, there is almost none. The expansion slots are completely different. The monitors are said to be specially designed for the 2000. The only common points seem to be the related CPU chips and the serial and parallel ports.

Several manufacturers, such as Tecmar, AST, and Quadram, have developed expansion boards for the IBM

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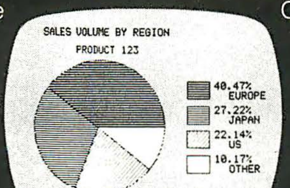
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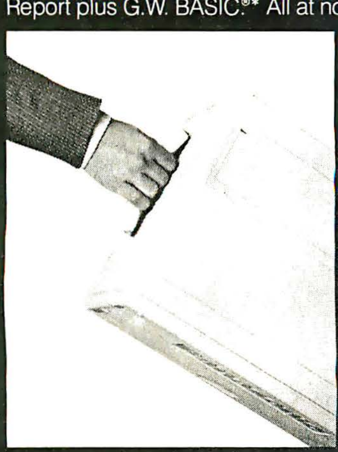
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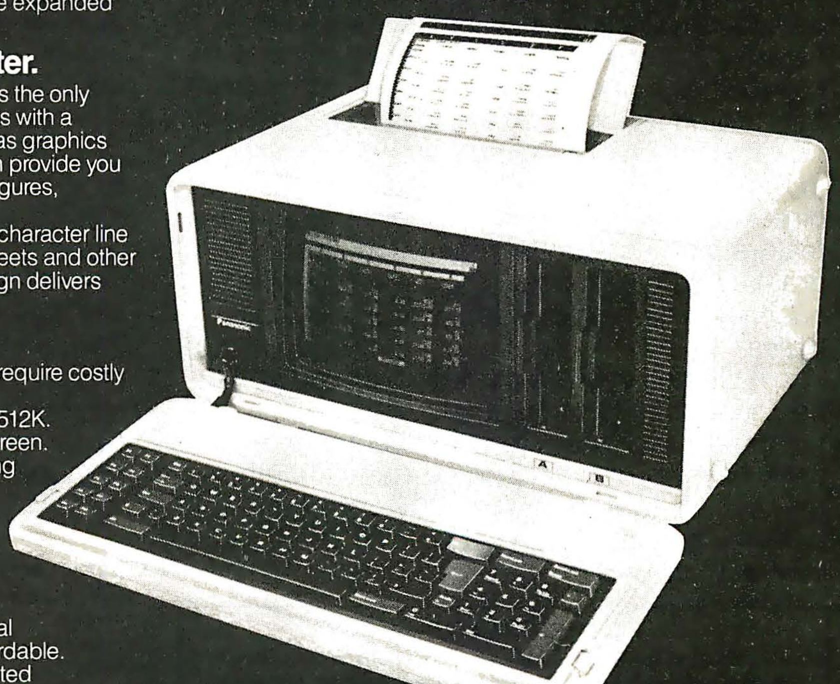
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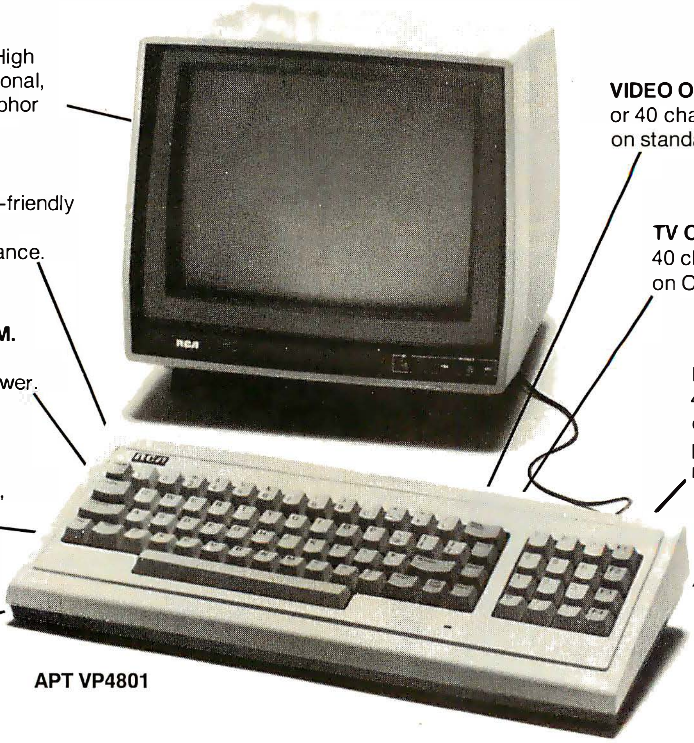


*Software package subject to change.

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PC. If these manufacturers will support the Tandy 2000 in the same way, the new machine's owners and Tandy itself will benefit greatly.

Apart from the IBM PC, the second area of compatibility is with other Radio Shack computers. Quite probably, the new 2000 will find its way into offices that already have a Model III or 4. Unfortunately, although they share the same disk size, they cannot read each other's disks. It would, of course, be too much to expect that these two different machines would run each other's programs. But it *might* sometimes be useful to be able to transfer a text file from the Model 4 to the 2000. Until someone writes a routine, you'll have to resort to using a serial cable.

Currently, the only visible compatibility with Models III and 4 is that the default disk drive is the lower one.

Conclusion

The designers at Radio Shack have corrected many of the faults present in the IBM PC, and, in some respects, have completely surpassed it. Most importantly, they have accomplished this at a very reasonable price.

Anyone who does serious number crunching should consider the 2000 (particularly if the 80187 chip appears). A significant amount of MS-DOS software will probably become available for this machine. But users who require a particular software package should first check if that software is compatible.

This new machine should be a very effective competitor for the IBM PC—it will allow Radio Shack to enter markets it has hitherto had difficulty penetrating. And, because of Radio Shack's formidable marketing, this strong product could spell trouble for some of the other MS-DOS machines on the market.■

Rich Malloy is BYTE's product-review editor.

In a future issue we hope to present a detailed System Review of this product that will include results of several benchmark programs and compatibility tests. . . . **R.M.**

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A Closer Look at the IBM PCjr

Comparing the PCjr to the PC and evaluating its performance and expandability

by G. Michael Vose and Richard S. Shuford

IBM finally starts shipping PCjrs to customers this month. As IBM dealers try to cope with an avalanche of initial orders, many questions remain about the machine's design, its operation, and its future in the volatile microcomputer market.

BYTE recently took a closer look at the PCjr. Our examination focused on the new machine's performance as compared to the IBM Personal Computer (PC); we also examined its expandability, compatibility with its big brother, and graphics capabilities. Our report reveals a few surprises (see the accompanying text box, "Benchmarking the PCjr," on page 324.)



Photo 1: *The IBM PCjr.*

The debut of IBM's home computer on November 1, 1983, provoked a cool media reception and a simultaneous outpouring of enthusiastic praise from personal computer market researchers. The microcomputer man on the street was glad to see the cat-and-mouse game between the media and Big Blue come to an end, quelling the hysteria to be the first to get the story, which is a distinction few people recognize. Besides, it had become clear that nobody would get the story until IBM wanted it released.

The media's reaction to the low-key presentation of the product, made at IBM's Gallery of Art and Science in New York, was lukewarm in part because the scribes viewed the PCjr, based on Intel's 8088 microprocessor, as being woefully short on state-of-the-art technology. What many of the press pundits failed to appreciate was that the PCjr, as the following pages demonstrate, is a product designed to do for the home market what the PC did for the business market—provide a solid, well-conceived, and well-designed machine backed by the world's largest computer company.

The press also seemed predisposed to criticize the PCjr in order to vent

the frustration built up during the months before the announcement by Big Blue's careful manipulation of information-gatherers to keep everyone off the track.

The market-research crowd crowed about the new machine, seeing it as the proverbial goose of golden-egg fame. The industry-watchers' only questions were, "Why are there no shipments before Christmas?" and "When will all of Big Blue's competitors file for Chapter 11?"

In the midst of this post-announcement media blitz, BYTE visited IBM's public relations office in Delray Beach, Florida, to get to know the PCjr.

Software Product	Price
Monster Math	$30
Animation Creation	$40
Mouser	$35
Scubaventure	$35
Homeword*	$75
Crossfire	$35
Mine Shaft	$35
Bumble Games*	$40
Juggles' Butterfly*	$35
Bumble Plot*	$40
Personal Communications Manager	$100
IBM PCjr BASIC (cartridge)	$75
Turtle Power	$50
Fixed Disk Organizer	$50
Adventures in Math	$35
DOS 2.10	$65
Home Budget, jr	$45
Casino Games 1.05	$35
Strategy Games 1.05	$30
Easywriter 1.15*	$175
pfs:FILE 1.05*	$140
pfs:REPORT 1.05*	$125
Time Manager 1.05*	$100
BASIC Program Development System 1.05	$130

*Prices will vary at authorized IBM Personal Computer dealers.

Table 1: *Software packages for the PCjr.*

A Description of the *PCjr*

The PCjr, billed by IBM as "the company's most affordable personal computer," is a repackaged, slightly redesigned IBM PC. (See "IBM Announces the PCjr," by Rich Malloy, December 1983 BYTE, page 358.) It comes in two versions, one with 64K bytes of memory that uses cartridge-based software, and the other with 128K bytes of memory and one double-density, double-sided disk drive with a capacity of 360K bytes. Major options include a thermal printer, joysticks, and a plug-in modem card. Table 1 shows the software products created especially for the PCjr, and table 2 lists a variety of IBM PC packages and their compatibility with the PCjr.

The PCjr comes in three separate pieces: keyboard, system unit, and power transformer. The transformer connects to a rear-mounted jack on the system unit and to a standard 110-volt, 60-Hz electrical outlet. The transformer drives a 33-watt, three-voltage-level, two-stage power supply.

The motherboard contains an Intel 8088 microprocessor running at 4.77 MHz. A power-on self-test routine, cassette BASIC interpreter and operating system, I/O (input/output) drivers, and a disk bootstrap loader are provided by 64K bytes of ROM (read-only memory). RAM (random-access read/write memory) consists of eight dynamic 64K by 1-bit chips with a 150-nanosecond access time. An expansion slot accepts a board providing an additional 64K bytes of RAM. The PCjr uses the Motorola MC6845 graphics display controller (see the section on graphics and display, page 326) and the Texas Instruments SN776486N three-voice sound chip (there is no internal speaker for this chip, but its output can be sent to an external speaker or to a TV speaker).

The machine includes a single serial port and interfaces for a joystick and a cassette recorder, along with dedicated expansion slots for an internal 300-bps (bits per second) modem and the disk controller. An optional parallel printer attachment connects to the right side of the system unit with four screws.

The only innovative technology employed in the PCjr is an infrared (IR) optical transmission link between the machine's keyboard and the system unit. (For additional information on IR technology, see "Use Infrared Communication for Remote Control," by Steve Ciarcia, April 1982 BYTE, page 40.) The IR link lets the keyboard be moved up to 20 feet from the system unit, as long as the keyboard remains in front of it. This optical-link technology is new to microcomputers but has been used for years in remote controllers for television sets.

IBM adopted this technology because it perceives that a home computer, used primarily in settings that do not include a desk, needs a keyboard unencumbered by an umbilical link to the rest of the machine. The company apparently feels that a home environment demands a more mobile keyboard and that the trade-off of an occasional lost character won't matter much in this application. A keyboard cord is available for people who don't feel comfortable with the infrared link and for applications, such as a classroom, where multiple PCjrs are in use. Connection of this cord disables the IR link.

The keyboard contains a CMOS (complementary metal-oxide semiconductor) version of the Intel 8048 microprocessor to handle the interpretation of keystrokes and serial encoding of keystroke data for transmission by two infrared-emitting diodes. The system unit contains an infrared receiver and circuitry to demodulate the 40-kHz carrier signal from the keyboard and send it on to the central processing unit.

The keyboard, when used without

Program Name/Version	Operates on IBM PCjr	Comments	Requires DOS 2.10	Requires BASIC Cartridge
Adventure/1.00	yes	cannot set foreground and background colors	no	no
Adventure in Serenia/1.00	yes	colors may vary from IBM PC	no	no
Adventures in Math/1.00	yes		no	yes
Animation Creation/1.00	yes	will run on an IBM PCjr with 64K memory	no	no
APL (A Programming Language)/1.00	no		n.a.	n.a.
Arithmetic Games (Set 1)/1.00	yes	no color on composite monitor	yes	yes
Arithmetic Games (Set 2)/1.00	yes	no color on composite monitor	yes	yes
Asynchronous Communications Support/2.00	no		n.a.	n.a.
BASIC Compiler/1.00	yes	must have sufficient storage for Compile and Link	yes	no
BASIC Primer/1.00	no		n.a.	n.a.
BASIC Programming Development System/1.05	yes	not recommended for IBM PCjr; use same procedure to load DOS 2.10 as for DOS 2.00	yes	no
Binary Synchronous 3270 Emulation/1.00	no		n.a.	n.a.
BPI Accounting Software (all)	no		n.a.	n.a.
Bumble Games/1.00	yes		no	yes
Bumble Plot/1.00	yes		no	yes
Casino Games/1.05	yes		no	yes
COBOL Compiler/1.00	no	compiler output will run on IBM PCjr if there is sufficient storage	n.a.	n.a.
Decathlon/1.00	no		n.a.	n.a.
Diskette Librarian/1.00	yes		yes	yes
Dow Jones Reporter/1.00	yes		yes	yes
Easywriter/1.15	yes		yes	no
Fact Track/1.00	no		n.a.	n.a.
Filecommand/1.00	yes	use same procedure to load DOS 2.10 as for DOS 2.00	yes	no
Fixed Disk Organizer/1.00	no		n.a.	n.a.
FORTRAN Compiler/1.00	no	compiler output will run on IBM PCjr if there is sufficient storage	n.a.	n.a.
Home Budget, jr/1.00	yes		yes	yes
Homeword/1.00	yes		no	no
Juggles' Butterfly/1.00	yes		no	yes
Learning DOS 2.00/1.00	no		n.a.	n.a.
Learning To Program in BASIC/1.00	no		n.a.	n.a.
Logo/1.00	yes		yes	no
Macro Assembler/1.00	yes		yes	no
Mailing List Manager/1.00	no		n.a.	n.a.
Monster Math/1.00	yes		no	yes
Multiplan/1.10	yes		yes	no
Multiplication Tables/1.00	no		n.a.	n.a.
One-Hundred-and-One Monochrome Mazes/1.00	no		n.a.	n.a.
Pascal Compiler/1.00	no	compiler output will run on IBM PCjr if there is sufficient storage	n.a.	n.a.
Peachtext/1.00	yes	not recommended for IBM PCjr	yes	no
Peachtree Accounting Software (all)	no		n.a.	n.a.
Personal Communications Manager/1.00	yes		no	no
Personal Editor/1.00	yes		yes	no
pfs:FILE/1.05	yes		yes	no
pfs:REPORT/1.05	yes		yes	no
Private Tutor/1.00	no		n.a.	n.a.
Professional Editor/1.00	yes		yes	no
SNA 3270 Emulation/RJE Support/1.00	no		n.a.	n.a.
Strategy Games/1.05	yes		no	yes
3101 Emulation/1.00	no		n.a.	n.a.
Time Manager/1.05	yes		yes	no
Turtle Power/1.00	yes		no	no
Typing Tutor/1.00	no		n.a.	n.a.
UCSD p-System (all products)	no		n.a.	n.a.
Visicalc/1.20	yes		yes	no
Word Proof/1.00	yes		yes	no

Table 2: *IBM PCjr software compatibility chart.*

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the optional cord, is powered by four AA batteries. The keyboard is in a perpetual standby state until a key is pressed. Only then do the 80C48 processor and the IR transmitter draw power. As soon as the character data has been transmitted, the keyboard reenters the standby, power-down mode.

The 62 unmarked, carbon-contact/rubber-dome keybuttons return scan codes rather than ASCII (American National Standard Code for Information Interchange) codes. (See "Compatibility" on page 328.) These keys will stymie the efforts of a touch-typist but will feel comfortable to children and novice computerists. We discovered a key-rollover problem when typing BASIC programs in. When three keys were pressed simultaneously, as is common with fast touch-typists, releasing the first two keys caused the machine to display the first and third characters; the second letter was lost.

The IR transmission link is susceptible to interference from very bright light, including sunlight, and high-voltage sources, including some television sets. The system unit issues loud beeps when there is high-energy interference affecting the unit; during our tests of the PCjr in IBM's office building in Delray Beach, these beeps were frequent enough to be annoying.

The absence of markings on the keybuttons requires a keyboard overlay for key labeling. The standard, attached overlay is color-coded and attractive but forces you to tilt the keyboard slightly forward to see the legends. An alternative would be to hunch forward to look down on the keyboard from a position above and perpendicular to it. Virtually everything about the keyboard, from the square, rubber-topped keybuttons to the overlay, and even the IR link, guarantees a vigorous after-market in keyboard replacements for the PCjr.

Benchmarking the PCjr

To evaluate the PCjr's performance, we ran a set of standard BYTE benchmark programs. These benchmarks were developed over the past two years and were used to evaluate the IBM PC (see "A Closer Look at the IBM PC," by Gregg Williams, January 1982 BYTE, page 36), the Victor 9000 (see "Victor Victorious: The Victor 9000 Computer," by Phil Lemmons, November 1982 BYTE, page 216) and numerous other popular microcomputers.

The PCjr we benchmarked contained the full 128K bytes of RAM and the color display adapter. The monitor used was the IBM Color Monitor. The test machine was "fully loaded" with optional peripherals.

Listing 1 shows BASIC benchmark programs developed by Richard Willis; the results are summarized in table c on the next page. The listings for the benchmarks summarized in table a can be found in the articles cited above. The Visicalc and Wordstar benchmarks consisted of: (1) a recalculation of a small spreadsheet containing two columns of numbers, six digits in one, seven in the other; (2) reading a large text file into memory, moving a page forward and back, and rewriting the file after making an editing change.

The three tables (a, b, and c) on the next page summarize the results of these benchmarks.

The Results

The PCjr executes BASIC programs from 24 percent to 32 percent slower than the PC. Because the BASIC interpreter in the two machines is fundamentally the same, this speed degradation is due to the screen update lag created by the PCjr's use of RAM for video buffering. Using main memory rather than a separate 16K bytes of RAM on the monochrome or color adapter display boards, as is the case with the PC, places the microprocessor in a wait state as often as two out of every three clock cycles while the screen updates. (See the section on graphics and display in the main text, page 326.)

The disk read/write operations in BASIC, not involving any significant screen updates, demonstrate a 15 percent to 24 percent slower execution time for disk reads and writes. The PCjr does not use direct memory access (DMA); the PC does. The use of DMA is largely responsible for the PC's outstanding performance in disk

Listing 1: *A benchmark program by Richard Willis. Results for these benchmarks are summarized in table c.*

```
10 '      ******
20 '   WRITE-TO-SCREEN
30 '(FIXED # OF DIGITS)
40 '
50 WIDTH 80
60 SCREEN 0
70 DEFINT I,J
80 J=12345
90 T0=TIMER
100 FOR I=1 TO 1000
110 PRINT J
120 NEXT I
130 T1=TIMER
140 TDIF=T1-T0
150 LPRINT USING "###.### SECONDS";TDIF
160 RETURN
170 ' BENCHMARK ROUTINE
180 '      ******
190 '   WRITE-TO-SCREEN
200 '(VARIABLE # OF DIGITS)
210 '
220 WIDTH 80
230 SCREEN 0
240 DEFINT I,J
250 J=12345
260 T0=TIMER
270 FOR I=1 TO 1000
280 PRINT I
290 NEXT I
300 T1=TIMER
310 TDIF=T1-T0
320 LPRINT USING "###.### SECONDS";TDIF
330 RETURN
340 ' BENCHMARK ROUTINE
350 '      ******
360 ' SCREEN 1 GRAPHICS
370 '
380 CLS
390 SCREEN 1
400 DEFINT I
410 T0=TIMER
420 FOR I=0 TO 319
430 LINE (I,0)-(319-I,199),I MOD 2
440 NEXT I
450 FOR I=0 TO 199
460 LINE (0,I)-(319,199-I),I MOD 2
470 NEXT I
480 T1=TIMER
490 TDIF=T1-T0
500 LPRINT USING "###.### SECONDS";TDIF
510 RETURN
520 ' BENCHMARK ROUTINE
530 '      ******
540 ' SCREEN 2 GRAPHICS
550 '
560 CLS
570 SCREEN 2
580 DEFINT I
590 T0=TIMER
600 FOR I=0 TO 639
610 LINE (I,0)-(639-I,199),I MOD 2
620 NEXT I
630 FOR I=0 TO 199
640 LINE (0,I)-(639,199-I),I MOD 2
650 NEXT I
660 T1=TIMER
670 TDIF=T1-T0
680 LPRINT USING "###.### SECONDS";TDIF
690 RETURN
700 ' BENCHMARK ROUTINE
```

The System Software

The base model of the PCjr comes with cassette BASIC in ROM. An enhanced version of BASIC, called Cartridge BASIC, is available for $75. This version of BASIC is comparable to the familiar IBM Advanced BASIC (BASICA), with some additional enhancements for graphics and sound and support for light pens and joysticks. The Cartridge BASIC is required to obtain disk BASIC file I/O functions.

PCjrs equipped with a disk drive use the $65 IBM PC-DOS 2.1 operating system, an upgrade of the earlier PC-DOS series. (BYTE will assess the modifications to this operating sys-

```
710 '       ******
720 '     BUBBLE SORT
730 '
740 DEFINT A,B,F,I
750 DIM A(50)
760 FOR I=1 TO 50
770 A(I)=51-I
780 NEXT I
790 T0=TIMER
800 F=0
810 FOR I=1 TO 49
820 IF A(I)=A(I+1) THEN 870
830 B=A(I)
840 A(I)=A(I+1)
850 A(I+1)=B
860 F=1
870 NEXT I
880 IF F=0 THEN 900
890 GOTO 800
900 T1=TIMER
910 TDIF=T1-T0
920 LPRINT USING "###.### SECONDS";TDIF
930 RETURN
940 ' BENCHMARK ROUTINE
950 '       ******
960 ' TEXT MANIPULATION
970 '
980 DEFINT I,J,K
990 DIM A$(1120)
1000 DIM B$(7)
1010 DIM C$(560)
1020 T0=TIMER
1030 FOR J=0 TO 4
1040 FOR I=1 TO 224
1050 K=(256*J+I+31) MOD 256
1060 A$(224*J+I)=CHR$(K)
1070 NEXT I
1080 NEXT J
1090 FOR J=1 TO 7
1100 B$(J)=""
1110 FOR I=1 TO 80
1120 B$(J)=B$(J)+A$(80*(J-1)+I)
1130 NEXT I
1140 NEXT J
1150 CLS
1160 FOR J=1 TO 7
1170 PRINT B$(J);
1180 NEXT J
1190 PRINT
1200 FOR I=1 TO 560
1210 C$(I)=A$(1121-I)
1220 IF ASC(C$(I))65 THEN 1250
1230 IF ASC(C$(I))90 THEN 1250
1240 GOTO 1260
1250 C$(I)=CHR$(176)
1260 NEXT I
1270 FOR J=1 TO 7
1280 B$(J)=""
1290 FOR I=1 TO 80
1300 B$(J)=B$(J)+C$(80*(J-1)+I)
1310 NEXT I
1320 NEXT J
1330 FOR J=1 TO 7
1340 PRINT B$(J);
1350 NEXT J
1360 T1=TIMER
1370 TDIF=T1-T0
1380 LPRINT USING "###.### SECONDS";TDIF
1390 RETURN
```

operations. The PCjr's performance in the absence of DMA is a testament to the efficiency of the disk routines in PC-DOS 2.1 and the hardware design of the slim-line drives.

(a)

Benchmark	IBM PC Time		PCjr Time	Ratio	4-MHz Z80 MBASIC 4.51 Time
empty loop	6.43		8.51	1.32	5.81
division	23.8		30.2	1.27	24.9
subroutine	12.4		16.0	1.30	9.4
MID$ search	23.0		29.6	1.29	18.6
sieve	190		236	1.24	151
disk (read)	31.9	28.7*	39.5	1.24	n.a.
disk (write)	28.5	29.6*	32.6	1.15	n.a.

* PC-DOS 2.0

Benchmarks for the PCjr against the PC and an 8-bit microcomputer: a 4-MHz Z80 running MBASIC 4.51. The ratio compares PCjr and PC performance. All times (in seconds) and ratios are valid to three significant digits.

(b)

Benchmark	IBM PC Time	PCjr Time	Ratio
Visicalc	1.59	3.68	2.31
Wordstar 3.24			
(read)	11.9	8.12	0.68
(write)	30.2	35.0	1.16
page forward	2.18	4.42	2.02
page back	2.24	4.46	2.04

Benchmarks comparing execution times for a Visicalc spreadsheet recalculation, Wordstar read/write operations, and page forward/back maneuvers in Wordstar using double-spaced text.

(c)

Benchmark	IBM PC Time	PCjr Time	Ratio
write screen (fixed)	50.2	41.8	0.83
write screen (variable)	48.9	37.8	0.77
medium-resolution graphics	23.7	31.8	1.34
high-resolution graphics	54.5	73.7	1.35
bubble sort	25.9	32.4	1.25
text manipulation	32.7	40.3	1.23

Benchmarks of a variety of tasks, as shown in listing 1.

tem in a future Technical Forum.) This operating system is designed for the entire IBM PC family of computers (referred to at the fall COMDEX technical presentations as consisting of the PC, PC XT, and PCjr only). PC-DOS 2.1 consumes 24,688 bytes of memory, compared to 24,576 for version 2.0.

Although the PC and the PC XT will run PC-DOS version 2.1 as well as versions 1.0, 1.1, and 2.0, the PCjr requires version 2.1. This requirement derives from new disk-interface routines dictated by the disk-drive hardware used in the PCjr. PC-DOS versions other than 2.1 may boot and run in the PCjr, according to IBM

dealer literature, but the company will guarantee data integrity with version 2.1 only. Our attempts to boot version 2.0 were unsuccessful.

The MODE command in PC-DOS 2.1 enables the alteration of the monitor's screen display in machines equipped with the 64K-byte Memory and Display Expansion board. The PCjr uses a 40-column display as a default because it is designed to be used with television sets, but the display format can be altered to display 80 columns with the DOS (disk operating system) command MODE 80.

The PC-DOS 2.1 system disk contains the files BASIC.COM and BASICA.COM. These files are the standard IBM PC disk and Advanced BASICs, respectively. They are for use only by the PC and the PC XT, however. The PCjr, whether using ROM or Cartridge BASIC, does not load or access these files. Commands to invoke BASIC are trapped and vectored directly to motherboard ROM or the cartridge vector address, as appropriate. For disk BASIC programming, 59,604 bytes of RAM (in a 128K-byte PCjr) are therefore available to the user.

Mode	Number of Colors	Compatible with Color/Graphics Adapter	Requires 64K-byte Memory and Display Expansion Board	Buffer Size (Bytes)
40-column alphanumeric	16	yes	no	2K
160 by 200	16	no	no	16K
320 by 200	4	yes	no	16K
640 by 200	2	yes	no	16K
80-column alphanumeric	16	yes	yes	4K
320 by 200	16	no	yes	32K
640 by 200	4	no	yes	32K

Table 3: *PCjr video modes.*

Graphics and Display

There is no expansion slot in the PCjr dedicated to a video-display adapter card, and with good reason: the video circuitry is built into the motherboard circuitry. Using the Motorola MC6845 for most of its functions, the video-graphics subsystem makes available several modes of operation that will be familiar to users of the PC's color/graphics adapter. But a new wrinkle has been added—a video gate array (VGA), the proprietary LSI5220 chip. The gate array makes possible two new high-bandwidth video-graphics modes that provide more colors at higher resolutions than were possible on the standard PC. There is also a new low-bandwidth graphics mode (see table 3). The PCjr can switch display modes without clearing the video buffer, enabling some new kinds of display manipulation.

The VGA provides a color-selection palette and separate selection of background (frame) color. A program can change the screen-display colors caused by a given set of display data merely by changing the values in the palette registers. Sixteen colors are available in the palette; in modes that use fewer colors, any combination can be chosen for display. Black-and-white display modes use a full gray scale.

The big difference from the PC's video architecture is that part of the main system memory must be used to contain the video-display data, thus the 8088 processor must share memory space and memory-access time. At least 16K bytes of memory must always be reserved for the display buffer, though only 2K bytes are used for a 40-column alphanumeric display, and the two high-bandwidth graphics modes require a 32K-byte buffer.

The designers of the PCjr did provide a measure of compatibility in display addressing; in early reports on the PCjr, this point was sometimes lost. In the big PC, the color/graphics display buffer, although separate from the main memory, is mapped into the 8088 processor's address space beginning at location hexadecimal B8000. The PCjr contains special address-mapping circuitry that traps memory references made by the 8088 to addresses in that region and redirects them into the low-range addresses of main memory where the PCjr's display data is kept, using a processor page register as an index. Consequently, some programs that bypass the operating-system display routines will run unmodified on the PCjr.

Because the main memory is shared, the processor and video-display circuitry must access it at different times. The 8088 can read or write memory during only one of every three memory clock cycles. Display refreshing takes place during the other two cycles. In the unexpanded PCjr, the first refresh memory cycle fetches a byte that contains the ASCII value of the character to be displayed via an 8-bit data path; the second refresh cycle fetches the display attribute of the character. But when the 64K-byte Memory and Display Expansion board is plugged into the PCjr, the memory addressing is reconfigured so that even-addressed bytes reside on the motherboard and odd bytes on the expansion card. During both refresh cycles, 16 bits of character and attribute data are fetched via a 16-bit data path, doubling the bandwidth of the display. The denser graphics modes and the 80-column alphanumeric mode require the greater bandwidth. In either case, the 8088 can get to memory every third memory cycle, or approximately every 1.1 microseconds.

All of this gives rise to a limitation of the PCjr: the unexpanded 64K-byte system cannot use several of the video modes; in fact, text display is restricted to 40 columns in the minimal unit.

The PCjr does not contain any circuitry to emulate the functions of the PC's monochrome display adapter, so the IBM Monochrome Display cannot be used with the PCjr. The IBM Color Display with its RGBI (separate red, green, blue, intensity) inputs works fine, but at $680 it's rather expensive for use with a computer that has a base price of $669. A radio-frequency modulator for using the

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computer with a TV is built in, but the cable to connect it costs $30. (And you wouldn't want to try viewing 80-column text on a TV.) You can also use a composite-video monitor. Like most of the PCjr's connections to external equipment, the cables plug into Berg-type pin connectors.

Compatibility

One of IBM's design goals for the PCjr was a certain amount of compatibility with its bigger siblings, the PC and the PC XT. As we have seen with the redirection of video-display addresses, the engineers took some effort to achieve this. Yet the PCjr is not 100-percent compatible with the other PCs. The contents of the ROM are certainly different, and there are certain hardware differences.

The incompatibilities between the members of the IBM PC family can be isolated into three categories: timing dependencies, unequal configurations, and actual hardware differences. Sources of incompatibility include the PCjr's smaller amount of memory, the lack of DMA (direct memory access) data transfers in the PCjr, different hardware addresses for the disk controller, and out-of-sync timing from the slower execution speed.

Even if there are no known sources of incompatibility, you can't be sure that a given program will run unless you try it. While visiting in Delray Beach, we tried to run a few pieces of IBM PC software we happened to have on hand.

Word processing proved to be a trove of success. Three popular programs—Sorcim's Superwriter (version 1.01), Mark of the Unicorn's Finalword (version 1.1), and Micropro's Wordstar (version 3.24)—seemed to run fine, although we didn't have time to exhaustively test every function. (We didn't have a copy of version 3.3 of Wordstar with us, so we don't know if the new program's direct screen accesses are compatible or not.) Jim Button's popular Freeware data-storage program, PC-File (version 8.6), also ran just fine, even though it had been compiled from BASIC under PC-DOS 1.1. But our string of successes ended when we tried Orion Software's J-Bird arcade game. Somehow the graphics display was hopelessly scrambled.

As IBM's technical staff emphasized during a seminar at COMDEX, the safest route for software compatibility is through use of the disk operating system. If relied upon for all services, the latest version of PC-DOS, 2.1, can shield application programs from the hardware differences. It remains to be seen if IBM's DOS software will provide support for all the functions that programmers need to write state-of-the-art code—support like that provided by Microsoft's Windows environment.

The PCjr keyboard is a good example of how the DOS shields programs from hardware differences. The keyboard has only 62 keys, as opposed to the 83 keys on the keyboards of the bigger machines, and the 62-key unit sends a different set of scan codes to the computer. But the DOS BIOS (basic input/output system) contains a routine to translate the scan codes to the same ones

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used by the 83-key setup. In this way, you can emulate any keystroke combination from the big PC on the PCjr's keyboard. (You can even emulate the Num Lock key, which produces a less-than-useful working condition on a keyboard without a numeric keypad, as one of us found by accident during our examination of the PCjr.)

Expandability

IBM states publicly that there are no architectural limits to memory or disk-storage expansion of the PCjr. The *IBM PCjr Technical Reference Manual* confirms that a 512K-byte block of 8088 address space is reserved for future user RAM (see figure 1).

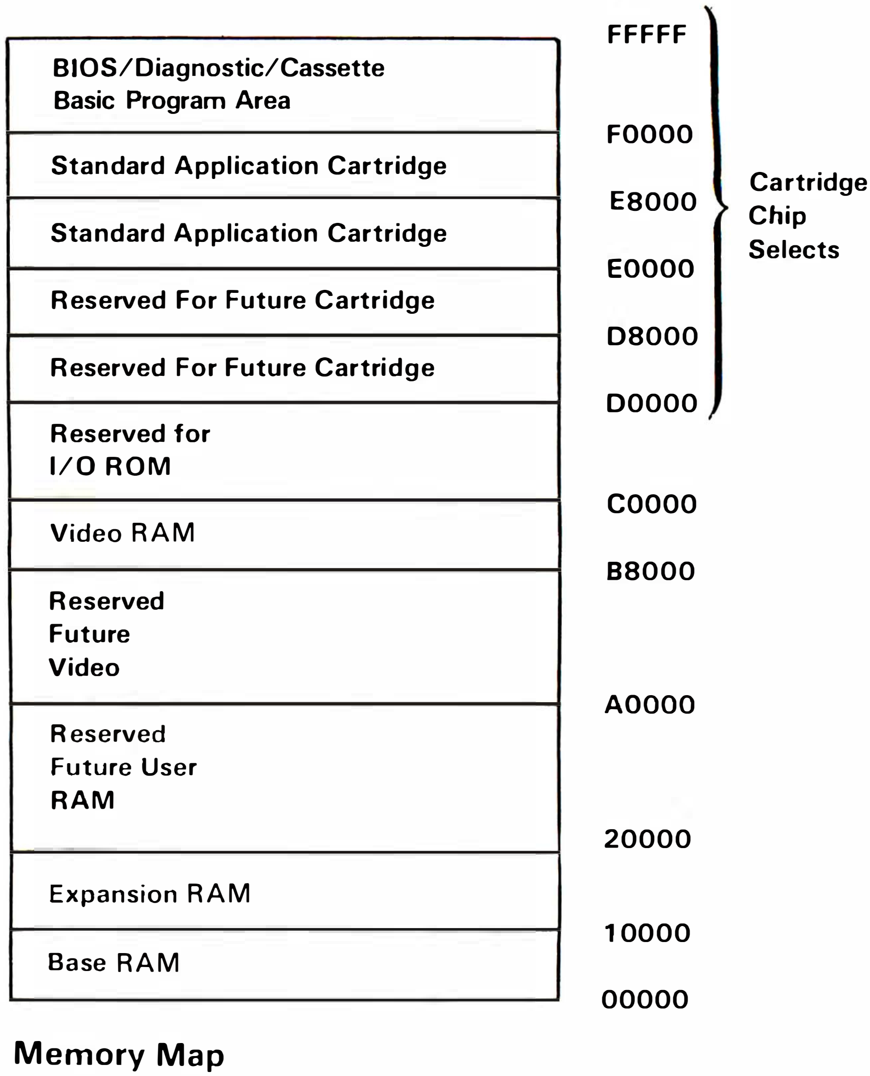


Figure 1: *The IBM PCjr memory map.*

Additional electrical power will be needed, however, for any expansion of RAM or disk storage. No room exists within the system-unit chassis for memory above 128K bytes, nor for another disk drive; therefore, expansion requires the use of the 60-pin I/O expansion bus. The power available at the connector for the expansion bus is limited to 400 mA of +5V DC. Because disk drives require +12V DC, no power is available at the connector for floppy expansion unless an additional power supply is provided. Similarly, 400 mA of +5V DC could marginally power 64K bytes of additional RAM, but expansion beyond this limit also requires additional power.

It seems likely that significant expansion will dictate a separate box containing power supply, additional RAM up to a maximum of 512K bytes, and one or more floppy drives and/or a hard disk. Because the electronics and housing for this kind of expansion unit could cost from $800 to $2500, expanding the PCjr is costly.

Expanding the basic PCjr unit with IBM peripherals could drive the cost to $2,073 for a system with 128K-byte RAM, disk drive, keyboard cord, thermal printer, joysticks, and carrying case. Other than cassette BASIC, there is no software bundled with the machine.

Conclusions

One surprise beneficiary of limitations in the PCjr's design will be the older generation of microcomputer-software vendors. Their products, largely derived from programs written for 8-bit computers, naturally work at their full capabilities in a relatively small memory space and with few system resources. It's the newer software houses—especially the ones whose products are "integrated" and therefore memory-hungry—that will gnash their teeth trying to figure out how to sell programs to owners of PCjrs.

Their molars may get relief, however, if the memory cavity enjoyed by the ROM cartridges can be filled. As much as 192K bytes of ROM could be addressed (with some ingenuity), enough perhaps to accommodate slimmed-down versions of some of the larger IBM PC packages. There are two other advantages to putting application programs in ROM: they execute faster (read-only memory needs no delays for refreshing), and the single floppy-disk drive is freed from program-loading duties; it can be dedicated to holding the application's data files. But it will take time for ROM-cartridge versions of popular programs to be produced.

The PCjr may turn out to be "the hobbyist's IBM." Unstymied by features left out of the design and attracted by the low (for IBM) cost, hobbyists and experimenters could soon be happily running a "poor man's clone" with wire-wrapped accessories hanging off on every side: an interface for a better keyboard, outboard memory expansion, and a DMA-based controller for a second floppy-disk drive connected by clip-leads to a Navy-surplus power sup-



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ply. Stimulus for ingenuity might turn out to be the biggest feature under the Peanut's shell.

The computer industry's rumor mill is still grinding with speculation that IBM will or will not support the PCjr, will or will not restrict production, will or will not produce upgrades for the machine. It's a popular pastime to be paranoid about IBM, but if the events surrounding the introduction of the PCjr are an indication, even the Blue Giant is finding it cannot absolutely control the volatile small-computer field.

The PCjr is appropriately designed for the home market. It is more affordable than the PC, yet it provides sufficient compatibility with its big brother to enable a worker to use a PC at the office and to work at home on the PCjr (with some limits) by simply transporting disks. In this context, the PCjr will seem awkward to use—the single floppy-disk drive will require much swapping of disks for format, copy, and backup operations, for example.

Although the PCjr is officially a home computer, you can be sure that IBM will try to sell it to schools and colleges, where students will be more tolerant than business users of the keyboard and the limited memory and storage. IBM is making the Logo language available for the PCjr, a strong hint of its desire to sell to the education market. Furthermore, IBM's dialect of BASIC is superior to that available on the Apple II and Commodore computers used by many schools (although the Extended BASIC for the TRS-80 Color Computer is almost as good).

The PCjr will be costly to expand for additional memory or disk storage. The new, low-cost bubble memory or EEPROM (electrically erasable programmable ROM) chips might be an alternative to a second disk drive.

The PCjr performs well compared with low-cost machines like the Commodore VIC-20 and 64, but it is slower than the PC. It cannot be compared in cost with most of the competing home computers.

The software and hardware aftermarkets for the PCjr will be vigorous. Vendors have already announced keyboard replacements, and several are planning to make memory-expansion boards to compete with the IBM board, which sells for $140.

There is still some question as to the magazine address space of the PCjr. Several publications have already been announced, and one, *PCjr*, published by Ziff-Davis, will have prepared three issues before customers begin receiving machines. Should the PCjr fail to attract a market, a lot of folks will be crushed by the resulting fall.■

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The Japan Shows

An Update on the Japanese Computing Scene

NEC introduces an impressive 16-bit computer, and Canon previews a remarkable, inexpensive laser printer

by Richard Willis

Business applications of microcomputers were the overriding emphasis at the 1983 Japan Data Show, held in Tokyo October 18–21, 1983. Individual personal computers took a back seat as computer makers put forward a wide range of networking and office-automation systems promising to transform the Japanese workplace into a futuristic information-intensive environment. But the home computer was also given its due. After a long, exhilarating day interfacing with the office workstation, tomorrow's Japanese workers will apparently look forward to spending the evening in front of their own ultrahigh fidelity, satellite downlink videotex banking and home-management terminals and laser-disk-driven arcades. At least that's the scene painted by some of the same manufacturers at the Japan Electronics Show, held the week before in Osaka. You have to wonder whether, at some point, people will start to overdose on all this technoculture.

Restraint is clearly not the operative term for describing the Japanese love affair with the latest electronic gadgetry—nor for describing the means by which such innovations are promoted. The Data Show and Electronics Show are cases in point. Big Japanese trade shows like these are an organized assault on all the bodily senses, at least an order of magnitude more intense than one experiences at NCC or COMDEX. Multimedia theaters at many of the larger firms' booths extol the exhibitor's technical wizardry, often with only minimal reference to specific products. Legions of young women sporting brightly colored blazers and overamplified microphones keep the halls brimming with decibels. Most of all, there are the crowds, a continuous human crush in the aisles and the booths that can only be compared to rush hour on the subway (see photo 1). A week-long NCC or COMDEX show in the U.S. may draw 100,000 to 150,000 visitors. The Japan Data Show, four days long on about the same amount of real estate, attracts close to 400,000.

Fewer Machines, Better Systems

The shows clearly revealed some new and significant movements within the Japanese microcomputer industry. Microcomputers are beginning to have a real impact on the Japanese workplace. Because even the simplest of business applications requires the computer to deal with *kanji* characters, microcomputers did not really begin to penetrate the business world until the introduction of 16-bit microprocessors. Even when the 16-bit machines first appeared, they left a lot to be desired in terms of software support, for their makers lacked the three or four years of hard-won business-market experience that benefited Western systems designers. Now, however, at least a few Japanese manufacturers seem to have realized the necessity of providing total systems packages, including a full range of applications software, for each new machine they introduce. And all the makers are working hard to improve their support of existing models by enhancing both hardware and software.

Almost every major firm at the Data Show was touting its new data-networking capabilities. But most of these systems were large-scale proprietary networks, specifically tailored to the needs and conditions in the Japanese office or factory and in many cases tied to one or more of the company's mainframe computers. There did not appear to be any standardized, compact network system emerging that might eventually have an impact on the American office-automation market.

And while software is receiving tremendous, much-needed emphasis in Japan, there is little or no consensus among computer makers as to which operating system (OS) to adopt. Microsoft got a jump on the market



Photo 1: *The 1983 Japan Data Show was fairly well attended.*

by developing a Japanese-language version of MS-DOS, currently the most widely used OS among garden-variety 16-bit machines. But some manufacturers had already started to develop their own proprietary operating systems for their high-end hardware. Others are abandoning standard operating systems in favor of building custom OS modules into each individual task-environment program, claiming that this strategy can improve performance substantially. Some machines provide a combination of stand-alone program modules (usually for word-processing and similar text-intensive tasks) and OS-dependent programs. And while some manufacturers have stuck with MS-DOS, others are moving to CP/M-86. There is considerable behind-the-scenes interest in Unix, but very few of the major manufacturers have introduced Unix packages for their machines, and its acceptance will probably remain in doubt until the next generation of processors arrives.

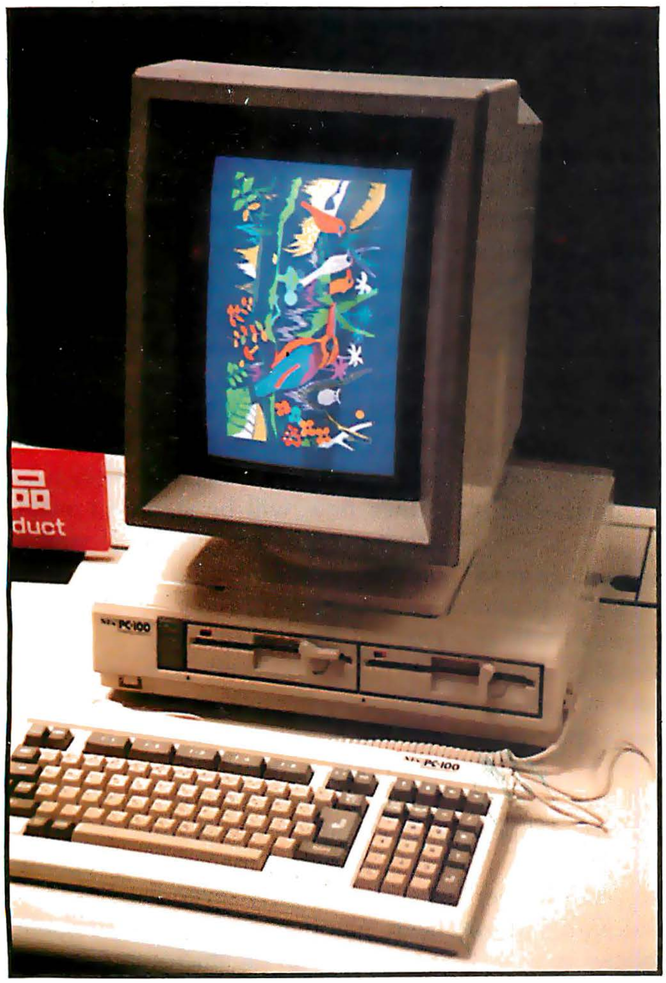


Photo 2: *NEC's new PC-100 8086-based system with a color display. A monochrome display is also available. Both CRTs can be turned horizontally.*

The effect of this fractious environment is, not surprisingly, to discourage independent software development, the force that has driven the American microcomputer industry ahead so vigorously. Most third-party software development is carried out under contract with a single large manufacturer for a specific machine. There are very few Japanese-written standard software packages (such as Visicalc or Wordstar), and it's doubtful that a healthy, inventive, *independent* software industry will emerge in Japan any time soon.

Recent BYTE reports from the Japanese computer shows ("New Japanese Microcomputers," April 1983, page 110, and "Update on Personal Computing in Japan," September 1983, page 250) have given fairly detailed summaries of the models produced by each of the major Japanese manufacturers, and most of these product lines have undergone incremental upgrading rather than total overhaul. Relatively few of the machines exhibited this year were new introductions. I will focus on those new systems that demonstrate significant technical advances or that typify major trends in the Japanese market, especially those that may soon affect us in the U.S.

Good News for Mouse Fans

Published surveys give Nippon Electric Corporation (NEC) over a third of the personal and desktop computer market in Japan, and the company shows no sign of

slacking off. In what was perhaps the most significant system introduction of the show, NEC unveiled its new PC-100, an 8086-based personal computer (see photo 2). This reasonably compact system is built around a very high-resolution display, a mouse, and a bundled software package. The 8086 processor runs at 7 MHz, and there is provision for an optional 8087 numeric coprocessor. The standard memory complement is 128K bytes of RAM (random-access read/write memory) expandable to 640K bytes, plus video RAM of 128K bytes for monochrome display or 512K bytes for color. The unit can be configured with one or two built-in 320K-byte 5¼-inch floppy-disk drives.

The video RAM is organized as a 1024 by 1024 bit map, of either one plane for monochrome or four planes for color. The 14-inch CRT (cathode-ray tube) display units offered with the system, both the monochrome (soft white) and the color, will display any 720- by 512-pixel window of the bit map, with smooth scrolling that can be controlled by either the mouse or a keystroke command. The color unit can display 16 colors from a palette of 512.

The real kicker is that the display can be turned vertically or horizontally to suit the application. In this characteristic, the system is similar to the Corvus Concept ("What a Concept," May 1983 BYTE, page 134). The user has a choice of four different *kana* or alphanumeric character formats (up to 64 lines of 120 characters) and two *kanji* character formats when the display is set horizontally, and three *kana* and one *kanji* format when the display is in its vertical orientation. A new type of display controller is used in this system; instead of employing its μPD7220 controller chip, NEC has designed an analog-output controller circuit, which may indicate that NEC plans to integrate the system with other video media in the future. Both the color and monochrome displays produce beautifully crisp visuals. All in all, the PC-100 sets a new high standard for personal computer graphics capability.

The two-button mouse that comes with the PC-100 is identical to the Microsoft mouse; Alps Electric, a major Japanese maker of electromechanical devices, developed it under contract from Microsoft and now sells or licenses it to NEC. The mouse's tail (cord) plugs handily into the right edge of the detached keyboard unit. The keyboard itself is extremely simple in layout, with the Japanese Industrial Standard (JIS) *kana* pattern and 10-key pad, five numbered function keys, and a bare minimum of special-purpose keys, all in a lightweight, low-profile enclosure.

The most revolutionary aspect of the PC-100 is that it is one of the first Japanese computers to come complete with a well-chosen package of software. The key element of the package is a Japanese-language word-processing program called JS-Word that employs a screen-icon-and-mouse control structure similar to the Apple Lisa or the new Microsoft Windows system. Up to eight overlapping windows, each carrying its own appropriate icons, can be opened on the screen at one time. Japanese textual material may be entered either in *kana* or in Roman-character equivalent form and then converted to *kanji*. Jean Yates, writing in a recent issue of *The Yates Perspective* (a newsletter covering software trends, with an emphasis on Unix) after a hands-on demo of JS-Word, describes it as one of the best word-processing programs she has seen, surpassing even Microsoft's Word (a fascinating irony because JS-Word was developed by ASCII-Microsoft, Microsoft's Japanese partner/subsidiary).

Also provided in the package are a Japanese-language version of Multiplan, a BASIC interpreter (whose program files, incidentally, can be edited by JS-Word), and some utilities, including software support for the standard RS-232C interface. The operating system is a Japanese-language version of MS-DOS dubbed version 2.01.

NEC clearly has designed a winner in the PC-100, a machine with a nearly perfect mix of capabilities at an impressive price: $2200 (in Japan) for a two-disk monochrome system with monitor, $3200 for color. A full *kanji*-capable, 18-magnet dot-matrix printer plus interface is available for another $1100. While the system does not have the total integration of different task environments offered by systems like the Lisa (you must load the various function programs separately and pass data via disk files), it goes a long way toward providing simple, accessible computing power and will undoubtedly appeal to many Japanese business and personal users. The question is whether this machine will be imported into the U.S.; the NEC spokesperson I talked to was noncommittal on this point. However, last May an NEC executive said that the PC-9801 (NEC's other new high-end computer) would not be exported but, rather, that NEC was developing a new machine with high-resolution graphics for introduction in America. So there is a very high probability that we will see the PC-100 here. It is also a good bet that it will feature a software package composed of Microsoft's Tools running under that company's Windows operating environment. If and when the PC-100 does show up in the U.S., it will certainly pose some stiff competition for Epson's QX-10 Valdocs system and perhaps also for Apple's mouse-and-icon-based Macintosh system.

The introduction of the PC-100 gives NEC a third 16-bit personal computer; the other two are the N5200 (sold in the U.S. as the APC; see October 1983 BYTE, page 280) and the PC-9801. Each of these machines now will be steered toward specific segments of the Japanese microcomputer market.

Daring Sordplay

While almost all Japanese companies are intensely competitive and ambitious, this year's prize for Most Audacious Agenda by a Start-Up Company must go to Sord Computer. Founded by a small group of very young engineers and programmers in the early seventies, Sord has been gaining steadily on its giant competitors in the microcomputer industry and now holds about 7 percent of the overall market (about 13 percent if the focus is narrowed to



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business microcomputers). One might expect a small company such as this to adopt a relatively cautious product strategy, choosing to address only a few markets that offered the best chance of success. Sord, however, has never shown the least sign of faintheartedness as it charged ahead, achieving (according to a recent study) the highest five-year sales-growth rate of any company in Japan. Sord's current line of microcomputer products, together with several new products to be introduced in the coming months, will put the company into virtually every microcomputer category, from video-game-oriented home computers, to portables, to business machines, to mainframe-challenging supermicrocomputers. All in all, Sord seems to be in an excellent position to continue its so-far spectacular growth.

Indicative of Sord's capabilities is its latest high-end machine, the M68, one of the first Japanese desktop computers to be built around the Motorola MC68000 16/32-bit microprocessor (see photo 3). The M68 runs its 68000 at 10 MHz and comes standard with 256K bytes of parity-checked RAM, expandable to 1 megabyte. It also includes an auxiliary Z80A on line with 128K bytes of additional video RAM. The Z80 can function as an I/O and display controller for the 16-bit system or it can be used to run existing 8-bit software under CP/M-80. It is augmented by an Am9511 (Advanced Micro Devices) arithmetic processor that performs 16- and 32-bit fixed-point and 32-bit floating-point arithmetic operations.

The M68's monochrome and color displays have a resolution of 640 by 400 pixels; 16 displayable colors can be chosen from a palette of almost 5000. This is excellent resolution for any sort of business graphics but a little coarse for CAD (computer-aided design) work, one of the more obvious applications for a system with such computing power. Sord is planning to offer a higher-resolution display with the M68 at some future date.



Photo 3: *The Sord M68, a 68000-based desktop system. In the spring of 1984, the machine will be available with 1 megabyte of RAM standard, expandable to 4 megabytes, using 256K-bit dynamic RAMs.*

The M68 comes standard with a pair of 1.2-megabyte 5¼-inch floppy-disk drives and two RS-232C ports, one Centronics and one IEEE-488 interface port. A hard-disk controller is built in, but the drives (either a 7.5-megabyte 5-inch or a 20-megabyte 8-inch) must be added externally. A pair of expansion slots can be fitted with specialized interface modules, including a network-communication controller, analog- or digital-signal interfaces, and a module that interfaces the M68 to an S-100 expansion chassis.

Sord is now exporting the M68 system to the U.S. at a very attractive price; a 256K-byte system with dual floppy-disk drives and a monochrome monitor lists for $4890. But the real bargain will arrive in the spring of '84, when Sord starts shipping M68s with Fujitsu 256K-bit dynamic RAMs installed. The base system will then have 1 megabyte of main memory and will sell for $5690 with a monochrome monitor or $5990 with color. Additional 1-megabyte memory modules—up to a total of 4 megabytes—can be added for $2390 each.

In the matter of software for the M68, Sord seems to have expansive plans, especially at the OS level. The company literature lists six operating systems that can be run, including CP/M-86, RDOS, the UCSD p-System, and a version of CP/M-80. With an optional 8088 module installed, the machine will run MS-DOS. And Sord is planning to release a Unix system for the M68 sometime in 1984.

At the same time that Sord is trying to be all things to all programmers, it is also continuing to promote its own proprietary software philosophy, as embodied in the package called PIPS (Pan-Information Processing System). PIPS is the pride and joy of Sord and probably is the best-known standard software package of Japanese origin. As Sord products start arriving in the U.S., PIPS will no doubt follow, heavily promoted.

The PIPS framework, designed by a banker, reflects a banker's way of looking at data (mainly numbers) in that all data in the system is thought to be organized in tables. At the heart of PIPS is a database manager; information is entered into the system in the same manner as to any relational database, though it is not clear whether the internal data structures of PIPS are true relational records or classical data tables. Once the database is established, it can be operated upon in various ways. The best analogy I can invoke here is that of a tool chest. The PIPS tool chest has several drawers, each containing a certain category of tools—Sorting and Searching, Arithmetic, Graphing, and so on. In general, only one drawer of the tool chest can be open at a time, but when you change drawers, you don't have to pick up all the data, put it away, and then pull it out again; the data of the table you're working on is always actively at hand. You call up the specific tools,



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or operations, to act upon the tabulated data by typing short mnemonic commands, as in Wordstar. Once you start a given process, the system will automatically request any additional parameters needed to define the operation. Unlike spreadsheet programs such as Visicalc, which are organized by cells, PIPS is column-oriented, so when you perform any operation that creates new data from existing data, you create a new column in the table. After the table has been stretched and scrambled and otherwise massaged to produce the desired results, various output formats, both tabular and graphic, can be specified for reporting the data. "Programs" in PIPS thus consist of sequences of table-manipulation commands.

First released in 1980, PIPS was the first real integrated package of software tools for microprocessors. In 1980, Software Arts (now Visicorp) was just starting to work on the file protocols that would allow Visicalc data to be passed to other Visitools, and Lotus's 1-2-3 was just science fiction. On the other hand, many aspects of PIPS—such as its confinement to columnar data structures—look rather primitive nowadays. However, the most sophisticated structures aren't always the most useful, and many people who work with financial data find the PIPS format intuitive and powerful. At any rate, Sord is constantly upgrading the package, so PIPS may someday attract some interest over here.

Mr. T Meets the Computer

Another of the major contenders in the Japanese microcomputer arena is Fujitsu, one of Japan's high-tech powerhouses, and the country's largest computer maker. Unlike many other firms now selling computers, Fujitsu did not start out making TVs, rice cookers, or cameras. Fujitsu's focus always has been on the industrial applications of electronics. Personal computers are Fujitsu's first venture over the rocky shoals of consumer marketing, but the company is apparently determined that it will not be out-hyped by anyone.

Fujitsu's presentation at the '83

Data Show exemplifies the trend toward building better systems around existing hardware. None of the microcomputers shown by Fujitsu this time were new (although some of the microprocessor-based workstations for the company's larger office computers were). The main attractions here were Fujitsu's proprietary fiber-optic "data highway," which tied a number of different machines on the floor into a large-scale mainframe at a company facility 10 miles away; a digital voice mail system capable of storing spoken messages and delivering them to integrated phone/data terminals; and a multichannel mobile data-communications system designed to support portable data terminals installed in automobiles (for salesmen, law-enforcement officers, and irrepressible hackers).

As far as personal computers were concerned, Fujitsu was standing firm on a fairly strong product line, the popular FM-7 8-bit and FM-11 16-bit machines. Also prominently featured was a 16-bit personal workstation computer, the 9450-II, which is now about a year old. This machine is the Ferrari of Fujitsu's personal computer line, but unlike the NEC PC-9801, with which it directly competes, I didn't see any huge stacks of 9450s bulging from the doorways of shops in Akihabara, Japan's mammoth retail electronic district. It seems that Fujitsu is conducting a more focused marketing program for the 9450, aiming to establish its credentials as a business machine rather than a mass-market toy.

Far from a toy, the 9450 employs a pair of MN1613s, a proprietary Fujitsu 16-bit microprocessor. The standard RAM complement is 256K bytes to 384K bytes. The unit can be configured with two 1-megabyte floppy disks, either 5¼-inch or 8-inch, or one floppy disk and one 10-megabyte hard disk. Display resolution is 640 by 480 pixels in both color and monochrome. The color display produced by this machine is as sharp and brilliant as any I have seen. Even though its *kanji* font is only 16 by 15 pixels, the characters are highly readable. An optional 8086 board is planned, although, surprisingly, the company says it intends to support CP/M-86 rather than MS-DOS.

The 9450 runs a proprietary multitasking operating system called APCS-III and offers an integrated package of business software—word processing, spreadsheet, graphics, and accounting—called the EPOC series.

One other Fujitsu product deserves special mention here, both for its technological achievement and its cultural overtones: the MyOASYS-2 personal word-processing system (see photo 4). This compact unit, about the size of the Otrona Attaché portable, has some rather powerful features for its size and price. For about $2200 you get a complete word-processing system, including a built-in video screen capable of displaying 14 lines of 40 *kana* or *kanji* characters or up to 80 alphanumeric characters, a 5¼-inch disk drive, and a printer, either thermal-transfer or wire-dot-matrix. Both the display and printer use a 16- by 16-pixel representation for *kanji* characters, with over 7200 character fonts stored in ROM. The system can perform semiautomatic *kana*-to-*kanji* conversion at the word level, with reference to a dictionary of about 40,000 words standard, plus up to 10,000 user-chosen readings. Additional disk-based software enables the MyOASYS-2 to perform simple graphics and calculations as well.

Every bit as interesting as the machine itself is the way in which the MyOASYS-2 is being promoted in Japan. Fujitsu has chosen Takamiyama, past winner of the Emperor's Cup (the grand championship of sumo wrestling) and one of Japan's best-known sports personalities, as the media representative for its MyOASYS series of word processors. You see Takamiyama's clowning visage plastered everywhere in Japan—in subway cars, on train platforms, and in full-size cardboard mannequins in front of computer



Photo 4: *Sumo wrestler Takamiyama demonstrates the portability of the Fujitsu MyOASYS-2 word processor. If asked, he could probably demonstrate the portability of a Subaru.*

(5a)



(5b)

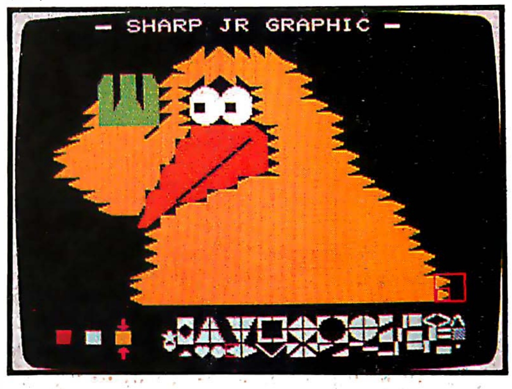


Photo 5: *5a shows Sharp's top-of-the-line office computer, the OA-8100, which employs a 68000 processor and supports Unix System III. 5b shows a TV graphic generated by the Sharp C1 home-graphics processor. Note the palette of shapes at the bottom of the screen. Pictures are created by "picking up" copies of the shapes and positioning them (by cursor movement) at the desired location on the screen. Memos also can be created by picking from a different palette.*

stores—but the sight of this 6-foot 3-inch 440-pound mountain of a man prancing (yes, prancing) across the TV screen, word processor in hand and three leotard-clad nymphets in tow, can only be compared to a certain scene from *Fantasia*!

See Sharp or Be Flat

If Fujitsu has worked its way down the scale from mainframes to microcomputers, Sharp has climbed upward, from pocket calculators. Sharp is number two in total PC sales in Japan but holds a much smaller share of the business computer market (about 6 percent), and the company is clearly aiming to improve that situation with its latest round of product introductions. Most significant of these is the OA-8100 (see photo 5), the only other 68000-based office computer besides the Sord M68 (and the OEM version of the M68 sold by Fuji-Xerox). What's more, Sharp has taken the plunge and is offering Unix System III with the 8100, even though a full *kanji* version of this operating system has yet to be developed. (This does not mean that applications packages running under Unix cannot use *kanji*, only that the system commands must be entered in English, if you can call "chmod," "mkdir," and "nroff" English.)

The 8100 comes in three configurations, numbered 8130, 8140, and 8150, the main difference being the disk complement. Memory capacity is 512K bytes to 4 megabytes. Various combinations of floppy- and hard-disk drives (10, 20, 40, 74, and 135 megabytes) can be ordered. The display has exceptionally high resolution—1152 by 750 pixels in monochrome and 768 by 550 pixels in color, with 16 colors displayable on the latter. The data sheet lists support for RS-232C and Ethernet interfaces, plus a circuit-switching/packet-switching communications controller.

The most popular of Sharp's serious personal computers, the cleverly packaged PC-5000, is now being sold in the U.S. This integrated unit, with a proprietary CMOS (complementary metal-oxide semiconductor) 8088-type microprocessor, 128K bytes of RAM, and an 80-character by 8-line LCD (liquid-crystal display) is priced at $1995, with an optional built-in thermal-transfer printer for an additional $395 and external dual floppy-disk drives for $995. This portable has several interesting systems features: its MS-DOS operating system is contained in one of three 64K-byte CMOS ROMs, the others being a system ROM and a BASIC interpreter ROM; in Japan, an additional *kanji* ROM module is added. The unit can accept 128K-byte nonvolatile magnetic bubble-memory cartridges. And dot-addressable graphics can be performed within its 640- by 80-pixel LCD. Weighing this machine's features—choice of microprocessor, memory capacity, display size, quality of keyboard, integrated printer, standard operating system, battery power—against its competition, the PC-5000 stacks up as one of the best values in the portable market.

In its new assault on the business market, Sharp has not abandoned the home-entertainment scene. The company is continuing to push the integration of the home computer with other electronic entertainment media. At this year's Electronics Show, Sharp added to its line the C1, a video game and graphics system



Photo 6: *Matsushita ("National" in Japan, "Panasonic" in the U.S.) showed its new portable voice-recognition module, the JH-600. The unit can be used by itself to recall short memos related to spoken inputs or can be connected to other systems as a controller or data-entry device.*

completely integrated into the cabinet of either a 14-inch or a 19-inch color TV. This system has nowhere near the capabilities of the Sharp X1 introduced last year ("New Japanese Computers," April 1983 BYTE, page 118) but seems instead to be intended for families with very young children. While the X1 can display 25 lines of 80 characters on its high-resolution color monitor, the C1's screen is organized (in the two interactive program modes) as 20 lines of 28 "blocks" each.

The C1 does not include a keyboard; instead, all interaction with the system is accomplished through a small controller box on a cord. This box has four cursor-control buttons, a Select button for stepping through a menu, a Start button, a Cursor Mode button to choose shape, color, or position modes, and a Pickup button. The Pickup button is the key element in the C1's elegantly simple human-interface scheme. In character mode, you simply move the cursor down into a chart of available characters (alphanumeric, *kana*, and just a few *kanji* for days of the week), position the cursor over the desired character, and press the Pickup button. Then when you move the cursor, it carries a copy of that character to anywhere in the array of blocks you wish to deposit it. In graphics mode, the pickup process is the same, except that the character chart is replaced by a palette of about 60 different shapes and five colors that can be used to create as sophisticated a display as any six-year-old is likely to conceive (see photo 5b).

While this human-interface system will never make the keyboard obsolete, it is certainly an excellent entry method for very young children. If Sharp were to implement a turtle-graphics capability into the system as well, it could be an unbeatable product. The C1 does have sufficient underlying graphic resolution for such an application because it also supports a number of video games in the form of cartridges that are plugged into the front of the console; a second controller box can be added for competitive games, and a game sound synthesizer is built into the system. Once a memo or graphic has been created, it can be saved to any audiocassette recorder. Unlike the X1, the C1 does not allow computer-generated graphics to be superimposed on regular television images. The 19-inch version of the C1 sells for about $640 in Japan.

Its Master's Voice

Like many American companies, the Japanese are experimenting with voice-entry systems. One or two firms at the show were demonstrating voice-recognition modules for their workstations. But the most remarkable voice-entry product I saw was a little portable machine from Matsushita (which uses the brand name National in Japan and Panasonic in the U.S.), the JH-600 Voice Recognition Computer (see photo 6). This unit is very similar in appearance to the company's JR-800 portable, except that the latter's 8-line by 36-character LCD has been replaced with a single-line 20-character display and a loudspeaker. Voice pickup is via external microphone.

The JH-600 is capable of recognizing as many as 62 different phrases up to 1.2 seconds in length, from either of two human speakers. Recognition is accomplished by pattern matching (using Walsh and Hadamard transforms) with phrases stored in the unit's memory. The total length of all stored phrases cannot exceed 42 seconds. To program the voice-recognition function, you first select a memo number, 1 to 62, and then type in a short memo that will be associated with the corresponding spoken input. This memo can be up to 36 characters in length and may or may not be an actual transcription of the word or phrase to be spoken. For example, you can store the spoken names of several people but put their phone numbers in the corresponding memo. After each memo is entered, you switch to voice-entry mode, press a button identifying yourself as either speaker A or B, and speak the desired word or phrase into the microphone. A light flashes to show that the entry has been accepted, and you then proceed to the next memo/phrase entry. Once all the desired phrases have been stored, you can

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Photo 7: *The Sony SMC-777 Z80-based home-graphics computer includes a single 3½-inch drive and lists for about $650 in Japan.*

switch to recognition mode, speak any one of the phrases, and see the corresponding memo pop up on the display. The pattern discrimination is quite powerful; in the noisy exhibition hall, the unit was able to distinguish between "Carrillo," "Cabrillo," and "Castillo," three freeway exits here in Santa Barbara that are often confused by human listeners taking directions over the phone.

In addition to displaying a memo for each phrase recognized, the JH-600 will transmit the memo number over three interfaces: an RS-232C port, a special interface for the company's JR-800 portable, and a 6-bit parallel control output. Thus the unit could be used to enter a predefined set of commands or other information into a larger personal computer. One application suggested by the manufacturer is the vocal entry of BASIC programs; the 62 possible phrases would hold most of the BASIC commands, a handful of variable names, and numbers 0 through 9. Just put the program editor in autonumber mode and start talking.

The JH-600 can function as a multistep programmable calculator and report its numerical results in synthesized (Japanese) speech. It can also act as a straight RS-232C terminal.

The unit employs a complex VLSI (very-large-scale integration) speech processor integrated circuit, and, at the time of the shows, Matsushita was still adjusting its process line to mass-produce the chips. Volume production of the JH-600 was due to start in early 1984, but no decision has been made on whether the unit will be exported to the U.S.

Matsushita was also displaying its new MSX-standard computer, the CF-2000. MSX is a combination hardware/software standard developed by Microsoft that theoretically allows home computers developed by various manufacturers to use each other's software. On the hardware side, MSX specifies a Z80 processor and a TI 9918 video controller and also defines other details such as I/O ports, joystick interfaces, etc. The standard software for MSX machines is a form of Microsoft BASIC. MSX has been accepted (in some instances grudgingly) by 18 companies at last report, including most of the major manufacturers of Japanese home computers.

The CF-2000 comes with 16K bytes of program RAM and another 16K bytes of video RAM. Up to two additional 16K-byte RAM modules can be plugged into the two cartridge slots, which also accept 48K-byte ROM cartridges containing such game hits as Boogie Woogie Jungle. The unit will generate a video display of 24 lines of either 32 or 40 characters; the character set includes alphanumerics, *kana*, 19 simple *kanji*, and some graphic symbols. The CF-2000 sells for about $230 in Japan.

It's a Sony

Sony introduced a couple of new home computers this time around, establishing a new HiTBiT product line (HiTBiT being an English play on the Japanese word *hitobito*, or "people"). One was an MSX-standard home computer, the HB-55, which will list for $230. This unit looked very similar to the Matsushita CF-2000—in fact, there were a half-dozen or more of these "cookie

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(8a)



(8b)



Photo 8: *Canon's new low-cost laser printer is shown in 8a. The unit has many similarities to the company's line of personal cartridge copiers. Although Canon plans to sell only the mechanism (8b), a prototype of a complete printer was on display at the Data Show.*

cutter" home computers at the shows; with little to recommend one over another. That's the down side of standards.

Sony's other release was much more interesting—a $650 home computer called the SMC-777 (see photo 7) with one of Sony's 3½-inch, 280K-byte microfloppy drives built in. This Z80-based machine comes with 64K bytes of program RAM and 38K bytes of video RAM and will generate a full 25-line by 80-character display on an RGB (red-green-blue) monitor or 25 lines of 40 characters on a TV (with external modulator). Graphics resolution is 640 by 200 pixels, 4-color, or 320 by 200 pixels, 16-color. Character and graphic displays can be superimposed. Also included is a TI 76489 sound-generator chip. Optional plug-in boards can be added to create a 4096-color palette, to provide *kanji* display capability, or to interface with the company's SMC-70 desktop computer. A second 3½-inch drive can be added externally. The SMC-777 does not conform to MSX, since that standard makes no provision for disks. A Sony spokesman in this country said the company had not decided whether to bring the SMC-777 to the U.S. For one thing, Sony isn't sure which of its marketing divisions should handle it.

International Marketing Agreements

While Apple did not have a booth in Tokyo, it was announced shortly before the show that the company had signed a nonexclusive distributor agreement with Canon Sales Ltd. under which Canon would take on the promotion and sales of Apple products in Japan. This should help Apple's position considerably; at last count, it had less than 1 percent of the Japanese market.

A number of marketing agreements are working in the other direction. For example, Mitsubishi has an extensive line of personal and office computers in Japan, hardly any of which are ever seen in the U.S. But the company is now producing an IBM-compatible PC clone that is being sold here by Sperry (under the Sperry trademark) and also by Leading Edge Products.

Canon's Peripheral Vision

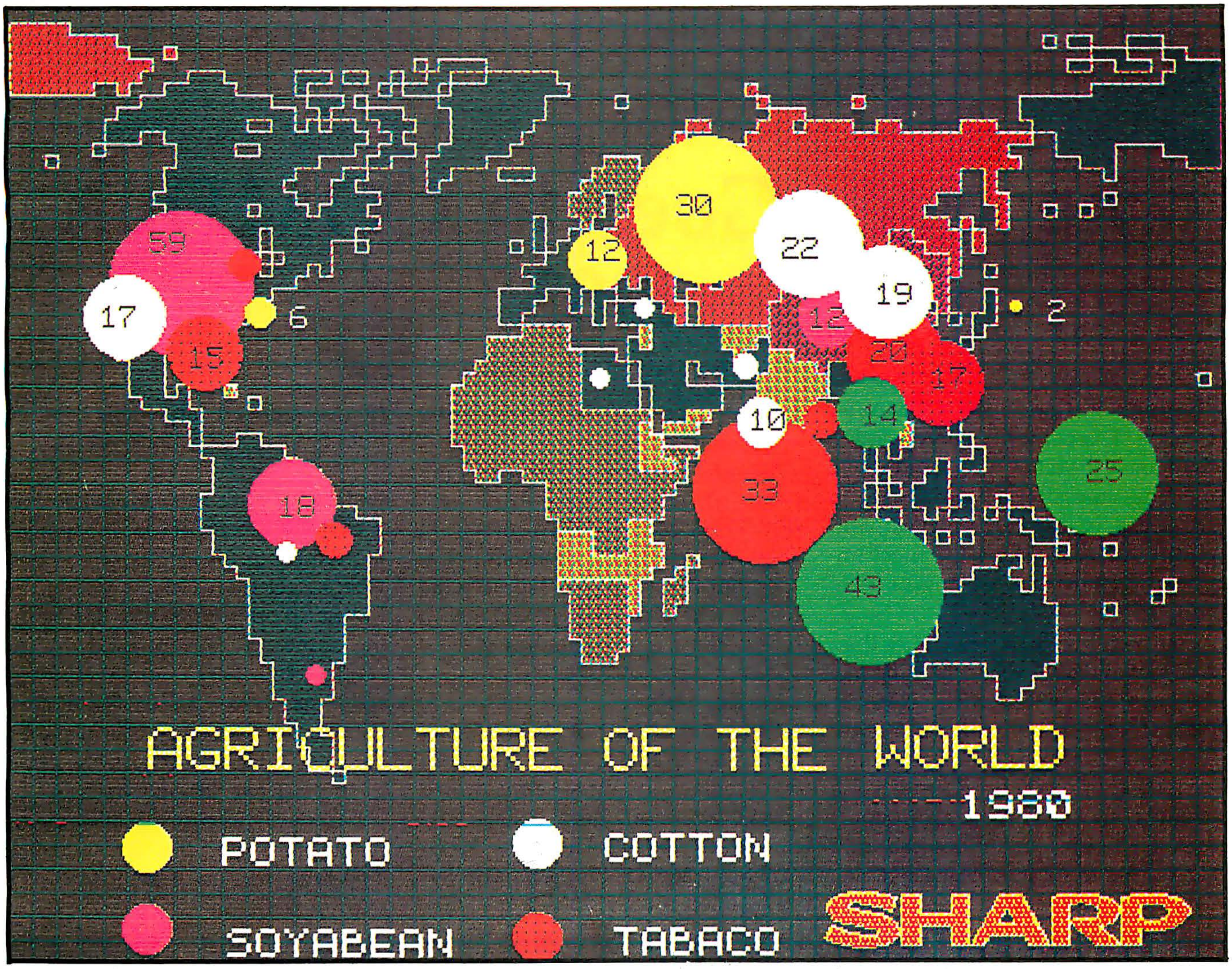
Far and away the most significant development in peripherals was Canon's new laser-printer mechanism, a device that could make high-end daisy-wheel printers obsolete. Canon has combined the cartridge copy system of its PC-10/PC-20 line of personal copiers with a laser-diode writing system to come up with the world's smallest, and least expensive, laser printer (see photo 8).

While the company says it has no current plans to sell complete printers directly to consumers, its OEM (original equipment manufacturer) prices for the print mechanism are remarkable—about $2000 for sample quantities, dropping to near $1000 in production quantities. For this price, the unit (called the LBP-CS) includes the entire printing system up to a serial video interface. From there, the end-product manufacturer would add font generation logic, timing and control electronics, and whichever form of data interface is desired.

This means that a straightforward office printer using the Canon mechanism could be brought to market in the $2500 to $3000 price range, landing squarely in the territory now occupied by high-speed daisy-wheel and dense-pattern dot-matrix printers. And the Canon system has the potential to far outperform these competing technologies. Its print speed is eight letter-size pages per minute, which for a character printer would correspond to more than 500 characters per second. The unit can generate images with a resolution of up to 300 dots per inch, about twice that of the best multipass dot-matrix printers. This will allow many different high-quality fonts to be produced, including, of course, *kanji* characters. And with appropriate interface electronics, all manner of graphic images can be created as well. Like the company's PC-10 and PC-20, the entire copy process—photosensitive drum, toner, etc.—is contained in a replaceable cartridge that's good for a few thousand copies. However, the cartridge used by the LBP-CS is different from that used by the copiers. For one thing, the drum has the opposite optical "polarity," i.e., it picks up toner in those areas that have been exposed by the laser radiation rather than where the dark printing of an original has been imaged.

All told, the Canon printer is a significant advance in hard-copy technology, especially in view of the fact that existing laser printers whose print specifications are not much better still cost 5 to 15 times as much. While the Canon is not designed for the sort of high-volume applications now being handled by laser printers, such as cranking out 10,000 invoices every day, it is perfectly suited for the small- to medium-size office environ-

(9a)



(9b)

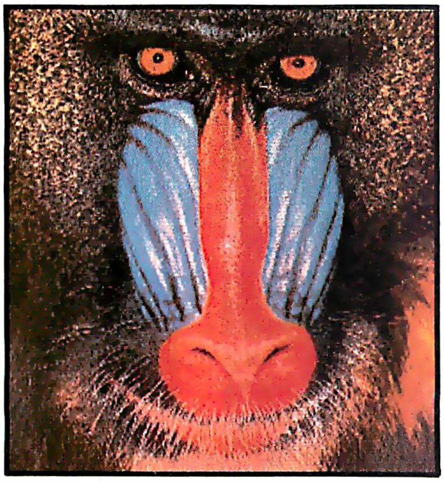


Photo 9: *Images from the new color printers shown in Tokyo. The resource map in 9a is from Sharp's scanned-head ink-jet printer. The baboon head (9b) was created by a sequential thermal-transfer printer driven by a video-frame-capture device.*

ment. A Canon representative said that several companies have begun to design end-market printers using the new mechanism but declined to say who they were.

A number of other developments in print technology were on display at the Data Show, most involving ink-jet and thermal-transfer printing. Both methods are now able to produce remarkably vivid full-color images. Two such images are shown in photo 9.

Storage Trends

The Japanese seem to be paying remarkably little attention to hard-disk storage, certainly nothing like the venture frenzy now being witnessed in this country. A couple of the majors were starting to show expanded-capacity 5¼-inch Winchester disks—up to 40 megabytes—but with business use of microcomputers just now picking up, it seems that most Japanese customers have yet to discover that they need more on-line storage than they can get with 8-inch floppy disks. Floppy-disk drives are moving forward, however, with the new preoccupation being *thinness*. Single drives are now available from a couple of manufacturers in a 28.5-mm (1.12-inch) height, and dual drives sharing the same motor are only 40 mm (1.57 inches) high. This would allow you to put *eight* floppy disks in an IBM PC if it had the power to run them.■

Richard Willis (POB F, Goleta, CA 93116) heads a small consulting firm specializing in electronic systems for production test and control applications. He received his master's degree in electrical engineering from Caltech in 1973 and has been studying Japanese at the University of California, Santa Barbara. He is a member of the Computer and Automated Systems Association of the Society of Manufacturing Engineers.

The User Goes to COMDEX, 1983

by Jerry Pournelle

I think it stands for COMputer Dealers EXposition. There's more than one COMDEX now, but the fall meeting, just after Thanksgiving in Las Vegas, is always the biggest, and traditionally it's where the most important new technologies are announced.

Fair warning. This year more than 80,000 attended to see something like 1500 exhibits (see photo 1). Clearly, I didn't look at them all. If I'd spent five minutes at each exhibit, it would have taken me two weeks to cover a five-day show. Thus, I can report only what I saw, and although I tried to find the most significant exhibits, I may have missed something important.

Second warning. Unlike my columns, in which I report on very little that I haven't tested myself, in show reports I talk about stuff I've seen but not tried. I presume what I saw will work when you get it home, but I can't guarantee it.

The Big Hits

Picking the "best of show" out of a zoo like COMDEX isn't easy; but I've singled out three items worth special attention. Each will be discussed in detail. They are Xerox Americare service, Ovation's wonderful new software, and Helix Labs' PC Bubble Disk.

Getting There Isn't Half the Fun

COMDEX is no place for users. It's too crowded. It's also nearly impossible to get there. My son Alex and I went up on Sunday, the day before the show officially opened. Weeks before, Rick Foss, our crack travel agent, had gotten our tickets. It didn't matter. The PSA flight was oversold. We were squeezed aboard the plane as the last two let on.

Two days before COMDEX we received an Eagle Spirit XL, which is a portable version of the IBM PC XT,



Photo 1: *The user's panoramic view of COMDEX.*

complete with a 10-megabyte hard disk. Eagle rushed the Spirit—we've named it Denny Colt—so we could take it to COMDEX.

I was also carrying Adeline, my Otrona. It's not that we didn't trust the Spirit, but I'd never traveled with it before, and I'd really hate being without a machine for a week. If Alex hadn't been with me I'd not have carried both; but it seemed the intelligent thing to do as we left the house.

Hah. It didn't seem so smart when we got on the airplane. Every seat was filled. So was every overhead rack. It turns out that the Apple people couldn't get flights from Silicon Valley to Las Vegas, so they went by way of Burbank—and they had *lots* of equipment. We gulped hard and prepared to stuff the machines under the seats and ride with our knees up to our chins; but that was not to be.

"That won't fit," one harried flight attendant said. "We had one just like it a few minutes ago, and it won't fit."

Now I'd have been much surprised if she'd ever seen an Eagle Spirit before, but there was no point in telling her. She'd made up her mind. We would have to check those computers.

By this time I'd lost most of my composure and a good part of my gruntle as well. My disposition wasn't helped by a mental picture of Adeline and Denny Colt tumbling down a baggage conveyor belt. I explained to the crew that tossing computers about wasn't a particularly desirable thing and sadly watched as they took both machines out . . .

It all came out well. Ms. Carol Franklin, the chief flight attendant, arranged to have a station agent meet the plane and hand-carry our machines. When we reached the hotel both worked flawlessly.

Incidentally, the Spirit *will* fit under both aisle and center seats, as we found when we returned from Las Vegas. You won't be very comfortable if you've legs as long as mine, but it can be done. It will also fit in overhead storage, provided the airplane *has* overhead racks; the one we returned on didn't.

A Maturing Industry

Sunday evening we registered and cruised through the exhibition hall to establish some landmarks. Monday morning was a press breakfast.

The big announcement was that a full year of Xerox Americare service will now be bundled with each Compupro business system sold. Xerox's Joe Cleary, Americare's honcho, had a few words about parts and service; Xerox has stockpiled a *lot* of spare parts for the machines it services. Those include Osborne computers, incidentally. Americare is completely separate from Xerox Computer. It doesn't sell anything but service.

You can buy different packages of services, with options for Americare to come to you, or vice versa, and so forth. The contracts aren't particularly cheap, but you wouldn't expect them to be. The important thing is that you can get service for a wide range of



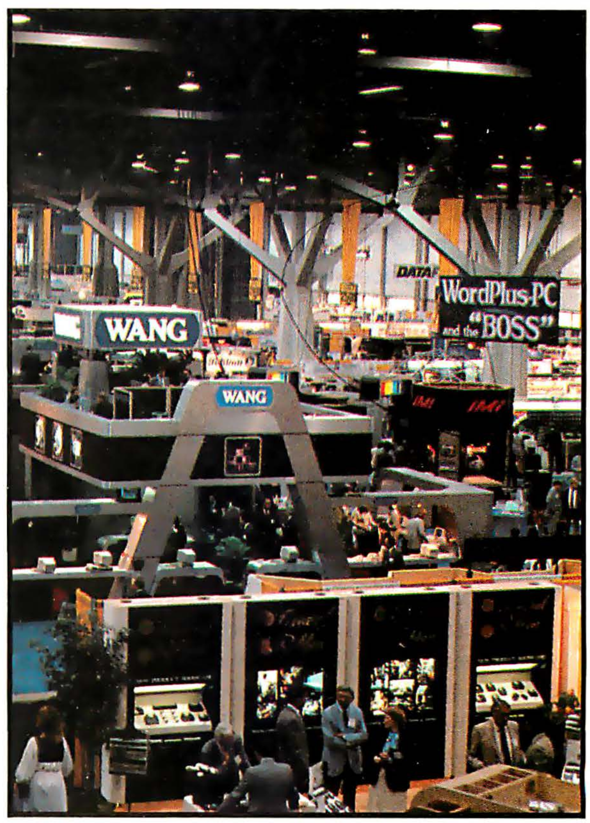




Photo 2: *The new and disdained keyboard arrangement from DEC.*

machines. (I wish I could list them, but my notes seem to be indecipherable. I'm usually not coherent in the early hours.)

At first thought Xerox Americare didn't seem like big news, but on reflection I think that in its quiet way this was the most important announcement of the show because it's a sign that the micro industry is mature enough to attract not just hobbyists and micro nuts, but small businesses. The availability of skilled outside service means we don't have to stay exclusively with the big companies. It also means the micro customer base is expanding, which means that prices will continue to fall.

It's good news for us all.

PC Compatible

The Las Vegas Convention Center is enormous. In addition, exhibits were also housed in the Sahara and Riviera Hotels, miles from the Convention Center. Not only were all the exhibition halls filled; a dozen smaller halls were also used. Every one of them, as well as the wider corridors, was filled with exhibits.

Half the exhibits were IBM PC look-alikes. I know, that's got to be an exaggeration; there aren't 750 computer companies in the world. Still, a *lot* of new computers were on display, and just about every one was billed as IBM PC compatible. "Look!" they exclaimed. "We look just like IBM, only we're *not* IBM. Isn't that amazing?"

I'm not so certain I'd want to be known as an imitator, but most of these companies want that very badly. We can call this "The Compatibility COMDEX." Even the beer and coffee were IBM PC compatible.

Of the PC work-alikes, the Eagle line remains my favorite, partly because I'm most familiar with them—I have both the Eagle 1600 and the Spirit XL—and partly because they go beyond "being just like" the IBM machines. The Eagles are faster and, in my judgment, better engineered.

Of the "just like IBM" machines, the one that most impressed me was the Panasonic. The company claims it's 100 percent compatible with the PC, and one of its salesmen told me he no longer carries software when he goes to demonstrate the Panasonic to dealers; he has them take PC software off their own shelves. He has, he says, yet to find PC software that won't run.

The Panasonic is portable, which is to say it has a handle and can be carried if you don't mind getting muscular biceps. It's *very* competitively priced and should be a real challenge to the Compaq and other "me-too" machines.

How Are the Mighty Fallen

Digital Equipment Corporation, aka DEC, had a large booth, but I didn't see many people at it. I don't know how many Rainbow computers DEC has sold, but I'd be very much surprised if the number approached Zenith's Z-100 sales.

DEC has come out with yet another lousy keyboard with a big key just to the left of the space bar that transmits a complex escape sequence, the **><** key between the Z and the left Shift, bad keys to interfere with hitting Return, and other such insults to touch-typists (see photo 2). DEC claims this keyboard will be standard on all its new offerings, including the new VT-200 replacements for the VT-100 terminal.

DEC is primarily a minicomputer company, of course. Part of the mini tradition is to isolate your customers from anyone else. Use a proprietary operating system, make people run software written just for your machine and useless for any other machine; that way you keep your customers away from the competition.

DEC made it, what with disk formats that no one else can read or write to and its own operating system. True, the Rainbow can run both 8- and 16-bit software, which is a big plus, but on the other hand, little outside software is currently available. DEC wanted to keep its people from using software written for the IBM PC. It succeeded beyond its wildest dreams.

I didn't notice one single exhibit advertise itself as "DEC compatible."

For the Most Important Person in My Life....

Last year we saw laser printers that could also double as your office copier. I had thought they'd be available at reasonable prices by summer, but I never saw any. John Carr, our long-suffering editorial associate, was getting fed up with not having a copier, so we went out and bought one of those Canon machines that you see Jack Klugman advertising.

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toner or other copier supplies because the Canon uses a cartridge system that's good for about 3000 copies. When it's used up, you put in a new one. The cartridges cost about $60 (that's about 2 cents a copy).

We got the model that has a paper-feed system. You can override that by inserting a sheet of paper, which means that you can make it print on both sides of the paper if you like.

We've been very pleased with it.

At COMDEX, Canon announced a laser printer built much like our Canon office copier. It uses the same paper-feed system, including the override feature, so you can hand-feed special paper (or print on both sides). It uses the same cartridge system. I couldn't tell whether the cartridges were identical to those in our copier. I'd be surprised if they were.

The model on display at COMDEX was really nice. It isn't any larger than our daisy-wheel printers, and it's *much* faster (about 12 pages a minute). The character set is very nice, and it's certainly a letter-quality printer. There's provision for full fonts: uppercase and lowercase, italics, small capitals, etc., as well as for special graphics, or for that matter, for downloading your own design. It doesn't have a tractor, but it does have a single-sheet feeder.

We've used our Canon office copier long enough to have considerable confidence in the cartridge system and sheet feeder being used.

I liked the Canon enough that I wanted one, but the company isn't selling them yet. All Canon would say is that you should be able to get one by the fall of 1984 and the end-user price will be less than $4000. Canon doesn't intend to sell direct to end users at all; it will sell the units to other manufacturers for incorporation into systems with a non-Canon brand name. I confess I was considerably impressed. Unless I hear good reason not to, I expect to get one when it comes out; I like the speed, and it's very quiet.

Big Bubbles

There was a lot of new hardware, including machines based on the Intel iAPX186 chip; but what impressed me most was Helix Laboratories' Helix PC Bubble Disk for the IBM PC. (Helix also makes them for Apple II and IIe machines.)

The Helix PC Bubble Disk is a board containing half a megabyte of bubble memory. You drop it into the PC, and the machine thinks this is a fast hard disk. It has its own ROM (read-only memory) aboard to read in the programs required to access it.

Because it's bubble memory, it's nonvolatile. You could even use it to transfer programs from one machine to another. It also has a write-protect switch (accessible from the back of the PC cabinet) and power-failure protection circuitry. Helix wants $1500 for the 500K-byte board, but when Intel lowers the price of the bubble chips, it expects to cut that by a hundred dollars or so.

We're getting a Helix PC Bubble Disk board, so there'll be a full report

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HEWLETT PACKARD

in an upcoming column. Meanwhile, I saw it running at COMDEX, and this is my choice for the most exciting new hardware at the show.

Mass Storage

Last year I speculated that if the industry could get together on the size and format of disk drives of 3+ inches, these drives plus memory drives and cartridge hard-disk drives would take over, leaving little place in the market for conventional 8-inch and 5¼-inch floppy disks.

That doesn't seem to be happening. Instead, even someone as conservative as I am now must admit that 5¼-inch technology is reliable and here to stay. That's not optimum, because when they designed 5¼-inch disks they didn't put in communications lines that let the machine know whether there's a disk in the drive. With 8-inch disks there's a hardware method of telling whether the drive is ready; thus, a "drive not ready" error can be compensated for. It's much harder to recover from that kind of error in 5¼-inch disks because there's no way for the machine to determine whether there's a disk present until it actually tries to read it.

Even so, 5¼-inch drives are gaining on the vest-pocket drives. I think that's a shame; the vest-pocket disks are, I think, more convenient, and certainly make for smaller and lighter machines. However, the industry's failure to agree on a standard—at least three sizes and formats are out there, each with powerful advocates—has hurt the vest-pocket disk's chances of taking over. Example: the Jonos, a really nice little portable, began with 3½-inch vest-pocket disks, but it can now be bought with 5¼-inch disks.

Meanwhile, few companies seem to have gone with the 5¼-inch removable hard-disk cartridges. These hold 5 megabytes and looked like a good deal last year, although my engineer friend Tony Pietsch was a bit concerned about some of the technical details. Whether it's spindle wear or something else, I didn't see any removable cartridge systems, although there may well have been some I overlooked. Certainly, they weren't very much in evidence.

However, Rana did have on display its new 2.5-megabyte 5¼-inch *floppy*-disk system. This is a special drive that uses a preformatted floppy disk. The formatted floppy disks will cost (initially) about $15 each. Compare that to $90 for a 5-megabyte hard-disk cartridge. Also, the Rana drive system will sell for less than removable hard disks. We're getting an early copy of the Rana 2.5-megabyte drive; full report in an upcoming column. Meanwhile, this new development may well be the salvation of floppies for some time to come.

Carrying the Mail

Tony Pietsch contracted with Bill Godbout to furnish WRITE, the text editor Tony wrote more or less to my specifications, for the Compupro 10, a multiuser system better known in my columns by the code name Shirley. Shirley uses the MP/M-8/16 operating system, which has some significantly different quirks from the CP/M 2.2x environment that WRITE was developed in. Tony ground up a new version of WRITE to run on Shirley, but he didn't get finished until the absolute last minute.

He also hadn't arranged for a hotel room. That turned out to be a mistake: nobody was accepting reservations in Las Vegas during COMDEX. Tony didn't want to go up and sleep in the park, so he prevailed on me to carry a copy of WRITE for Shirley, which I duly did. Of course, there were a couple of system options and switches that had to be set right, and nobody knew how to do that, so it took a couple of phone calls to Pasadena to get WRITE going; but by Monday afternoon, I could see WRITE running on four different terminals, all powered by the same central machine.

Interestingly enough, running four at once didn't slow things down at all; at least I didn't notice anything, with one exception. When you write to the hard disk, you have to wait your turn; so if two users try to save text at the same time, one has to wait while the other gets done. Even with waiting it takes about as long to save on Shirley as it takes me to save onto floppies with my single-user system.

A Standing Ovation

Ovation Technologies has what may be the best microcomputer software I've ever seen.

I met Robert Kutnick, Ovation's director of development, at the Tandy press breakfast. The Ovation software was running on one of the new Tandy 2000 machines. Alas, I was more concerned with talking with the Tandy design people—on that, see below—and thus never saw a demonstration of Ovation with that machine. However, Dr. Kutnick was kind enough to give me a ride from Caesar's Palace, where the breakfast was, to the Convention Center, and during the ride he invited me to come see Ovation's product.

I went more out of gratitude for the ride than anything else. I don't usually watch software demonstrations; I prefer to get the stuff to Chaos Manor and bang on it myself. Worse, Ovation didn't even have its software running in its exhibit booth; for marketing reasons I don't need to understand, it was exhibiting the Real Thing only up in its suite in the Hilton.

It's nearly impossible to get anywhere in the Hilton during COMDEX. There aren't enough elevators, and there are too many people looking for free dinner and drinks at hospitality suites. However, the Ovation suite was on the same floor as the Xerox Americare party I was going to, so it wasn't hard to stop by, which I did, and wow! am I glad.

Ovation has a combination text editor and spreadsheet that interact so that the overall effect is wonderful.

Let me describe. You write a letter. In the letter you put some numbers. Now you go through and put the cursor on each number. You can give that number a *variable name*. The name is known to the computer; the number in the letter stays the same. But *now* you can redefine that variable as, say, the sum of some other variables. When you do, kazango!, the number is changed in the letter.

There's more. Now assume you want to make a graph. You use the



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cursor to open a hole in the letter; that's where the graph will be printed. Now you put the cursor on each number you want to be in the graph, or specify the variable name associated with the number; touch a special function key; and, kazango!, there's your graph, right there in the middle of the letter.

Suppose it was a pie graph and you decide to change to a bar graph. Nothing to it. Now, use the cursor to change one of the bars on the graph—and the number in the text instantly changes to match it!

There's more, but you get the idea.

I don't recommend that people go out and buy software until I've had a chance to wring it out, examine the documents, test it at boundaries, and the like. On the other hand, Ovation isn't ready to sell the program this week anyway.

We're getting Ovation here Real Soon Now. I can hardly wait. It's potentially the most powerful micro software I've ever seen; and it's real easy to use, too. Before you buy a spreadsheet or text editor for your IBM PC, do try to look at Ovation. You might like it.

Tandy Strikes Again

Tandy introduced its Model 2000 at a press breakfast in Caesar's Palace. After speeches by at least four different people, each of whom repeated what the last one had said, they literally unveiled the machines, which had previously been covered with a tablecloth.

It's nice-looking equipment.

The Tandy 2000—there's nowhere on it the words "Radio Shack"; apparently the company is a bit concerned about its image with the business community, as indeed it darned well ought to be—uses an Intel iAPX186 chip. The "one-eight-six," as it's known in the development community, is one of Intel's 8086 family. It will run any software developed for the 8086 and 8088 chips. It also has some unique instructions of its own, and it's a lot faster than the 8086 or 8088.

What this means is that any PC-DOS software that's hardware independent (not written specifically to

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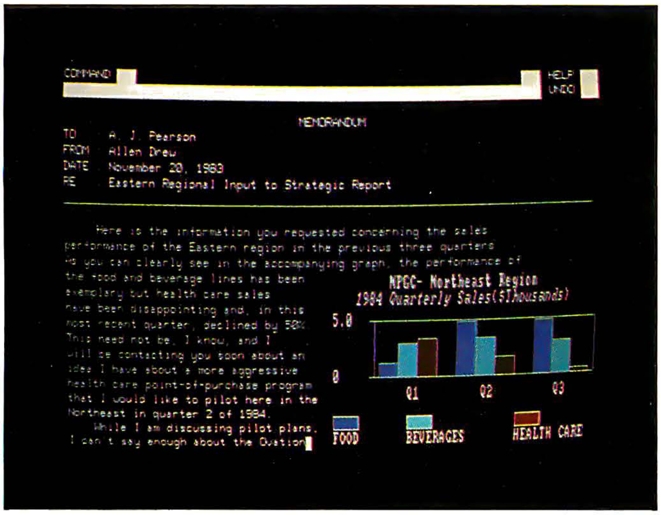


Photo 3: *Color graphics on the Tandy Model 2000. Monochrome is standard, but color doesn't cost much more. The Model 2000 shows all the signs of being a great success if the Radio Shack image can be overcome. But can Tandy get enough 80186s to build the 2000?*



Photo 4: *The Zenith 25-inch RGB monitor. The Zenith Z-100 is running Microsoft's Windows program. You can read it from across the booth. Zenith also showed its newest 13-inch RGB monitor intended for both Zenith and IBM products.*

make use of the IBM PC's graphics and such like) will run with the Tandy 2000. However, there may be problems with some copy-protected software.

The machine will be described in great detail in other BYTE articles, so I'll only mention my impressions. (See "The Tandy TRS-80 Model 2000" on page 306.)

First, we liked the color graphics (see photo 3). The machine seems fast, and it does a nice job with its extensive color capabilities. Alex will probably have more to say on that; he's the graphics freak in Chaos Manor.

Second, it looks like a good, well-made machine, with good all-around capability.

Incidentally, the Tandy 2000 is going with Microsoft operating systems, including Xenix. It's my impression that more companies are drawing away from Xenix, which is a Microsoft "sort of Unix," than are adopting it.

Zenith

Zorro, our Z-100, has become a workhorse here, so I was glad to see new Zenith products. The most impressive was a 25-inch RGB (red-green-blue) monitor. It was displaying Microsoft's new Windows program on a Z-100. Believe me, a 25-inch monitor is *big* (see photo 4).

Zenith also announced an 8087 board for the Z-100. Jim Hudson, who developed the 8087 math board for our Compupro, also has an 8087 for the Z-100. The Zenith one is much simpler, only four chips; Hudson's board uses an S-100 slot and contains 256K bytes of memory. We're getting both boards, so I'll be able to report on them in a future column. Meanwhile, there's a growing list of software that makes use of the 8087. It's a worthwhile capability if you do any number crunching at all; the 8087 does floating-point arithmetic about a zillion times faster than the 8086.

Meanwhile, the Hudson and Zenith boards have different niches, and I expect them to coexist.

Alex notes: "Zenith put a quieter fan on its new Z-100s. Even in the noise and haste of COMDEX it was noticeable." That makes me wonder if I can get one of the new fans and retrofit it; we like Zorro, but he is a bit noisy. Alex also notes that the new ROMs and BIOS (basic input/output system) for the Z-100 are much advanced over the versions we have, and it's time to update. Apparently Zenith has made update offers to people who bought its machines, but since Zorro still belongs to Zenith Data Systems we don't always get the notices, alas.

It wasn't at the Zenith booth, but we saw the Macrotech 1-megabyte memory board working in a Z-100. Macrotech's memory still has the lowest cost per kilobyte, as far as I can tell, anyway.

We continue to hear the rumor that Zenith will come out with a Z-100 with a detached keyboard, but there was no sign of one at the show. Maybe it is just a rumor after all.

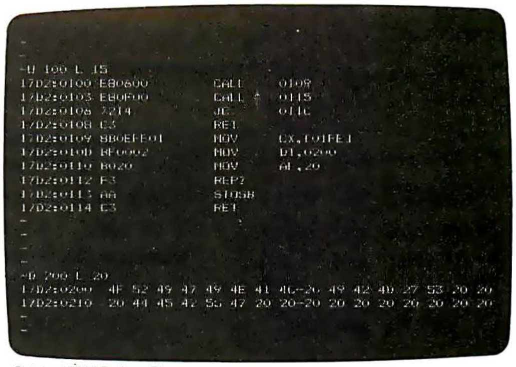
MPI

Zenith also had the Printmate 150 printer in its booth. This is our favorite dot-matrix printer, for reasons I've given in the column. Having an outside printer in a Zenith booth is a first, since previously only Heath stores carried the Printmate.

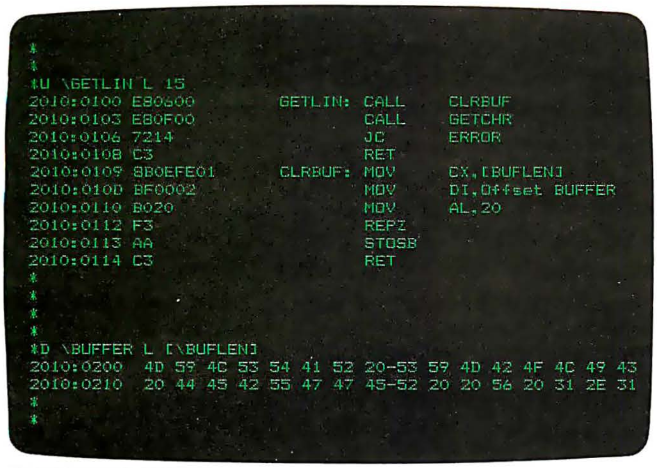
MPI, "The Printer People," was displaying the Sprinter in its own booth. The Sprinter is a small portable printer. Like the Printmate 99, it can take tractor feed or single sheets of paper such as letterhead; and like the 150, it has the capability for up to 68K bytes of print buffering.

The Sprinter comes in a hard shell case and is designed to be rugged enough to go as checked luggage. John Matlock of MPI has taken his on three trips now and swears that the only signs of travel are some black marks on the case. I was supposed to receive a demonstration model of the Sprinter at COMDEX so I could test that myself, but Alex and I were so burdened with stuff that we just

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couldn't carry anything more. MPI is shipping one instead, and I'll carry it on my next few lecture tours. I continue to be impressed with MPI's printers.

The portability of the Sprinter generated some humorous advertising, including buttons that said "Handle me," and "Pick me up," and "I'll go with anybody," which seemed a bit daring for a Salt Lake City firm . . .

Teletype

Teletype is back in micro land with a terminal. It's a bit expensive, about $1500, but it has a number of pages, lots of memory, and lots of features. It may well be worth it.

When I went into the Teletype exhibit area, I was approached by a young salesman.

"I want a five-level Baudot machine," I said wickedly.

He was completely nonplussed. Fortunately, a sales manager was nearby, who said, "In the Smithsonian, I imagine."

After all, in the early days of the micro revolution, old Teletype electromechanical bangers were often the only terminal equipment we could get, which is why one of the "devices" in CP/M is to this day the TTY: or Teletype. It's also why to this day some programs have the Delete key "echo" the deleted letter; if you're using the Teletype as a console, it has to be that way because a TTY can't backspace.

Alas, for all its early dominance, Teletype didn't understand what was happening and made no concessions to the micro revolution; and whereas most micro people owned some kind of Teletype device early on, it wasn't long before the micro community had left the company behind.

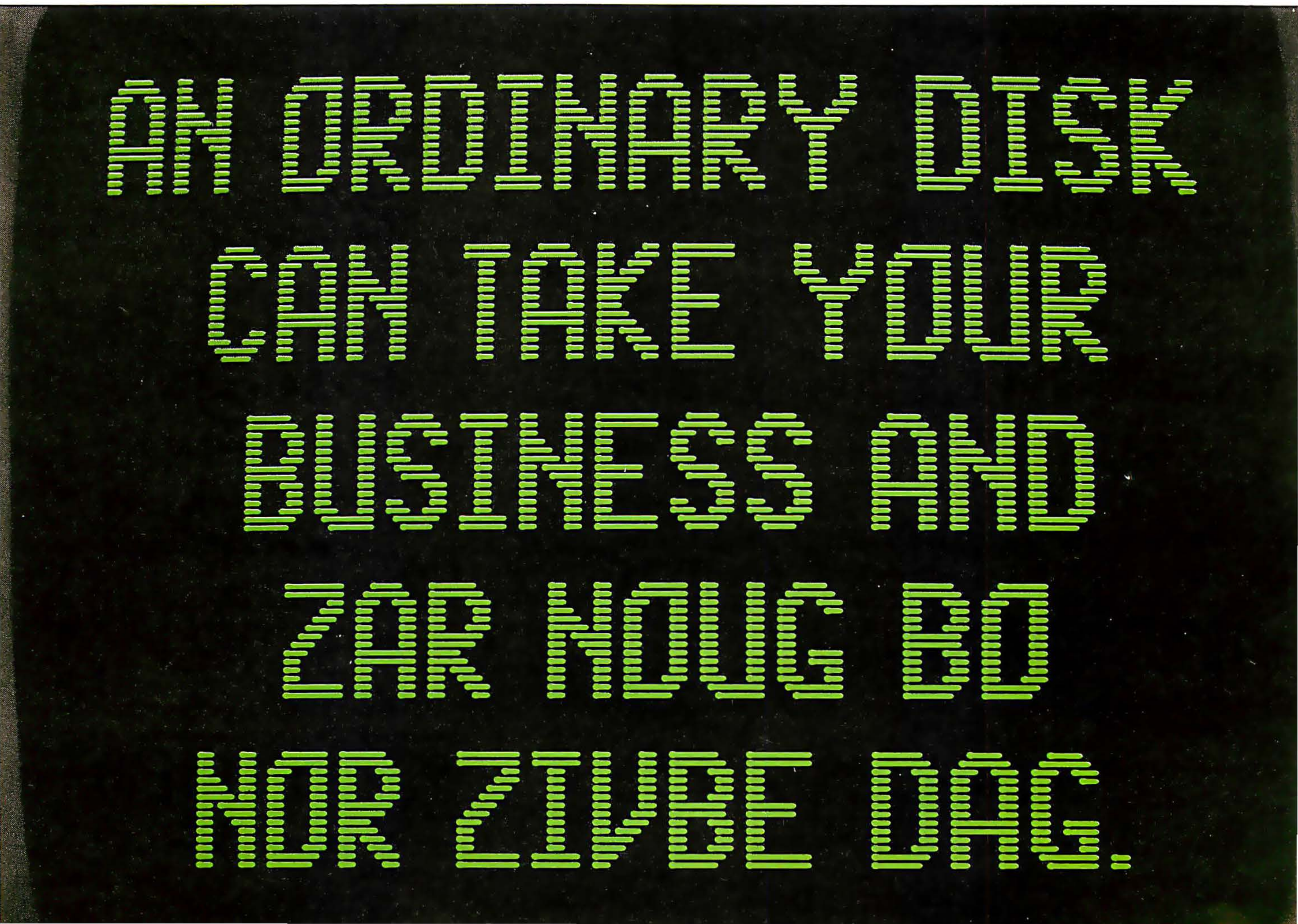
I don't really miss the sound of the old TTY banging away, and I'm sure glad I don't have to remember what five-level Baudot is; but I'm also glad to see Teletype coming back. It's like welcoming the return of an old friend.

Because the Hilton exhibit area is in a direct line between the Hilton lobby and the main Convention Center, it was always full of traffic.

The Mad Computer

The Mad machine was over in the Hilton exhibition hall; this was exceedingly hard to get to because the security people *never* let us in before show hours, and because the Hilton exhibit area is in a direct line between the Hilton lobby and the main Convention Center, it was always full of traffic. I very nearly didn't go in there at all.

Alex did get there, and persuaded me to go see the Mad computer. He votes the Mad "best-looking computer in the show," and says, "It has one well-kept secret: it has IBM slots in it. Another module can hold four more IBM PC cards. Because it uses the Intel iAPX186 chip, it can't use IBM memory boards (because the 186 is a true 16-bit device, and Big Blue stayed with an 8-bit bus). Most other



expansion boards should work fine."

Alex also noted, "The gimmicks for Mad are impressively different: modularity and ergonomics. The basic computer has two modules: the computing module and the data module. The computing module has the processor, memory, two serial ports, one parallel port, video, and keyboard interface. The data modules contain either two half-high IBM-type floppies or one floppy and a 10-megabyte hard disk. Of course, you can buy the hard-disk module later and run both. Interestingly, the hard disk is powered by the main computer.

"The Mad's screen has 720- by 350-dot resolution; add more RAMs, get more resolution. The keyboard (and the whole computer) conforms to European ergonomics standards, but it still looks good. It has a Selectric keyboard layout, without extra keys in the wrong places. If you're looking for a machine that will look good in the office while working well, look at the Mad."

I did note that Mad claims high compatibility with the IBM PC, while running much faster than the PC. It certainly is a handsome machine. Alex and I played about with one for a while, and it's quite fast. Like the Eagle, it's an improvement on the PC rather than just a copy.

Mad claims high compatibility with the IBM PC, while running much faster; like the Eagle, it's an improvement on the PC rather than just a copy.

Networks

A number of networking systems were on display; so many that Alex makes them (along with windows) one of the two themes of this year's COMDEX.

Networking is a subject of sufficient complexity that I want to deal with it in the column rather than in a show report. For here, I'll just report that there are a lot of ways to get computers to talk to each other, and no one standard method has emerged.

This was one of Bill Godbout's laments at his press breakfast. Compupro has taken a firmly wishy-washy stand on networks by cutting holes and covers for a bewildering variety of plugs and jacks and sockets on the back of its machines. Godbout did cite some studies that indicate that perhaps the best network arrangement is nodal, with perhaps four machines connected together into a node, then one connection from that to similar nodes. The Compupro 10 is a four-user system, which isn't a total coincidence.

Corvus, meanwhile, has taken a firm stand for Omninet. No wonder, since it's its baby. Omninet has the advantage that the cable connecting systems is simple—just twisted pairs of wires—and the maximum distance between nodes can be about 2000 feet. This is almost as long as Ethernet, which uses coaxial cable and is 10 times as fast but more than twice as expensive. We have a Corvus system here, and we're beginning to

string twisted pairs of wire from the back room to my office, so we'll be able to report in detail later.

Meanwhile, there's no agreement on what will be *the* network; but there's wide agreement that networking is desirable.

Bottom Line

COMDEX is huge. If you don't believe that, consider that I was a week in Las Vegas and didn't manage to make one single wager. Now true, I'm hardly a gambling man, but I do like to buy about $50 worth of chips and shoot craps until it's gone; but not this time. Between the breakfasts and the evening receptions and the dinner parties, I found COMDEX all work and very little play.

It's a strenuous show, and I don't recommend that readers go to it; but it's a must for anyone trying to keep up with this bewildering world of microcomputers.

Onward and upward. I love it.■

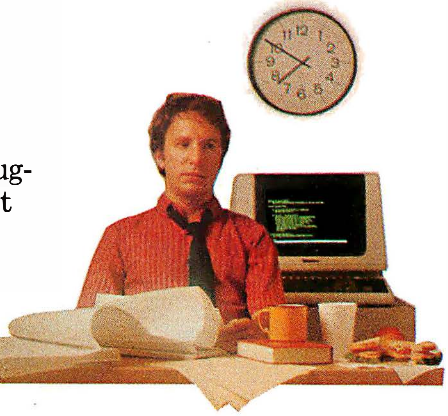
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Jerry Pournelle is a former aerospace engineer and current science-fiction writer who loves to play with computers.

Products Mentioned

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Canon U.S.A. Inc. One Canon Plaza Lake Success, NY 11042 (516) 488-6700	Laser Printer
Compupro 3506 Breakwater Court Hayward, CA 94545 (415) 786-0909	Compupro 10 WRITE
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Digital Equipment Corporation 146 Main St. Maynard, MA 01754 (617) 897-5111	Keyboard
Eagle Computer 983 University Ave. Los Gatos, CA 95030 (408) 395-5005	Eagle 1600 Series Eagle Spirit XL
Helix Labs 16776 Bernardo Center Dr. Ste. 106A San Diego, CA 92128 (619) 451-0270	Helix PC Bubble Disk
Jonos Ltd. 1835-A Dawns Way Fullerton, CA 92631 (714) 999-6661	Jonos Computer
Macrotech International Corporation 20630 Lassen St. Chatsworth, CA 91311 (818) 700-1501	Memory Board
Mad Computer Inc. 3350 Scott Blvd., Bldg. 13 Santa Clara, CA 95051 (408) 980-0840	Mad Computer
MPI 4426 South Century Dr. Salt Lake City, UT 84107 (801) 263-3081	Printmate 99 Printmate 150 Sprinter
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Panasonic Consumer Products One Panasonic Way Secaucus, NJ 07094 (201) 348-7000	Panasonic Computer
Rana Disk Systems 21300 Superior St. Chatsworth, CA 91311 (818) 709-5484	2.5-megabyte System
Tandy Corporation One Tandy Center Fort Worth, TX 76102 (817) 390-3011	Model 2000
Teletype Corporation 5555 West Touhy Ave. Skokie, IL 60077 (312) 982-2000	Terminal
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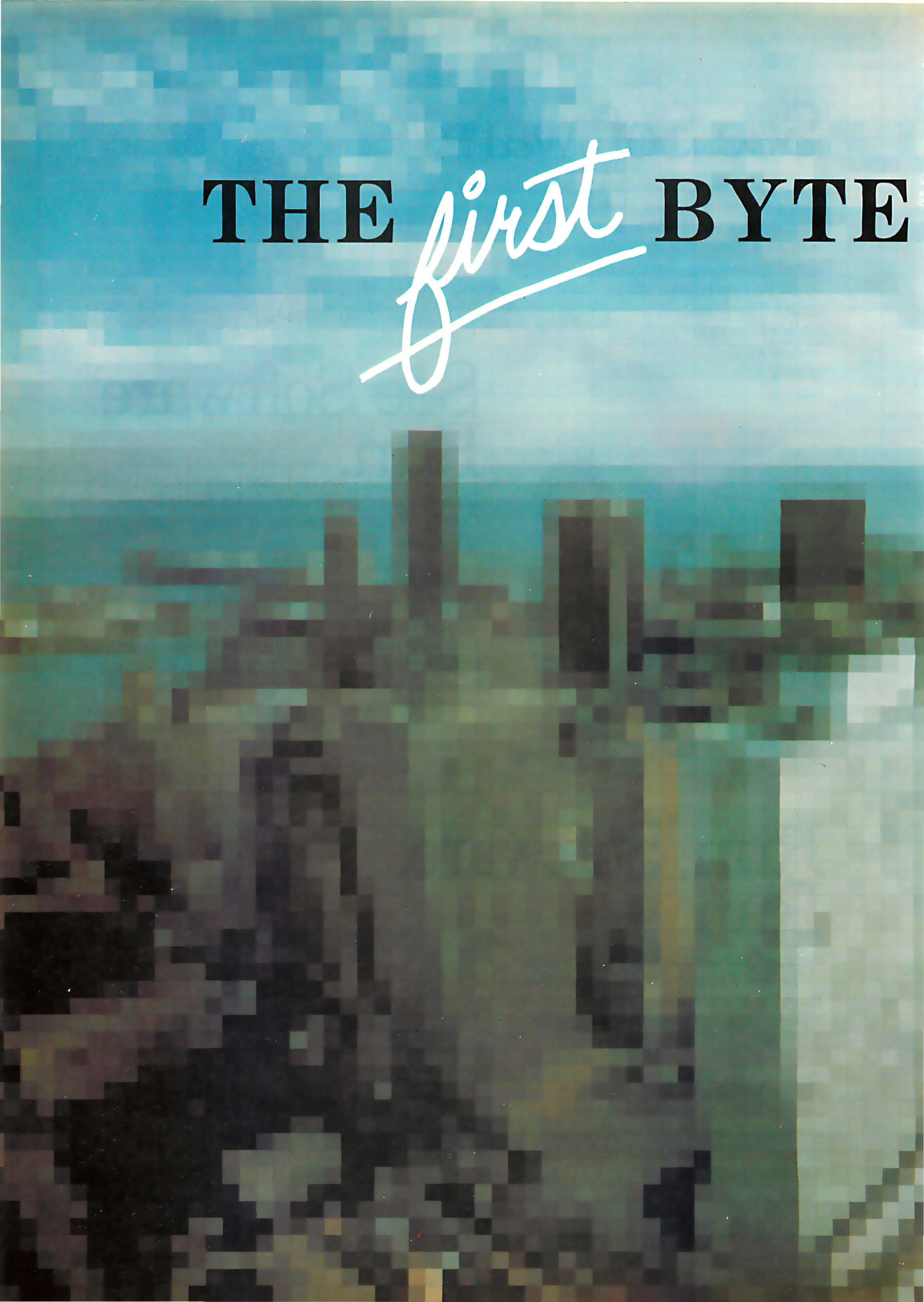


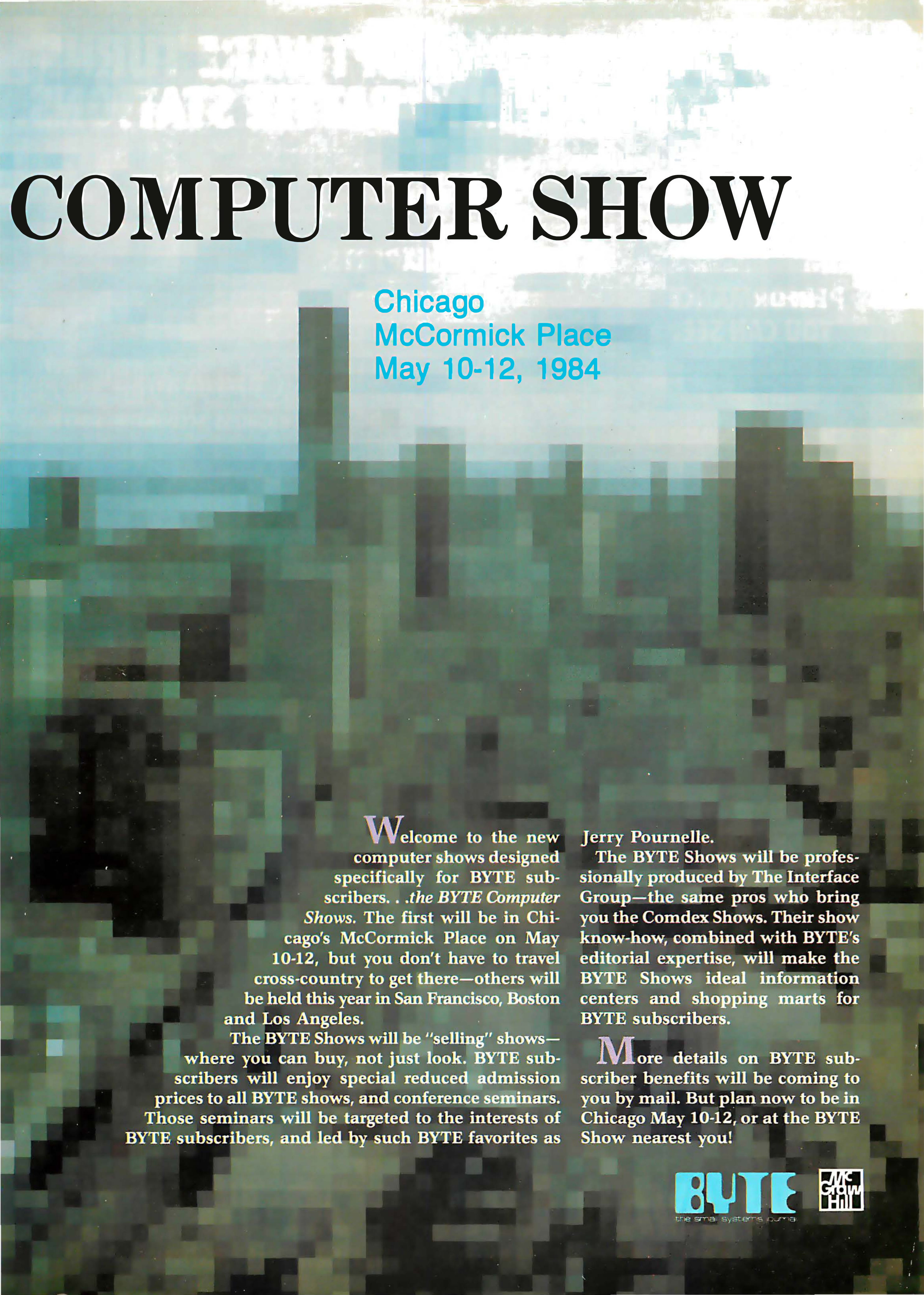
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Pascal's Design Flaws

Modula-2 Solutions and Pascal Patches

A description of seven subtle problems with Pascal, and a look at how Modula-2 avoids them

by Mark C. Johnson and Allen Munro, Behavioral Technology Laboratories

Niklaus Wirth was only warming to the task of creating the perfect programming language when he developed Pascal. If you regularly program in Pascal you probably have pet peeves about its "bugs" or "gaps"—the design flaws of the language that you encounter again and again. Pascal, like other languages originally designed to teach computer programming, has several serious deficiencies. Wirth's newest structured language, Modula-2, remedies some of Pascal's flaws and also provides mechanisms to enforce modular program design more strictly than does Pascal.

The most important components of Modula-2 are not its ability to "fix" Pascal's structure, but rather the features associated with the concept of the module. Modules provide for secure independent development of different portions of a program in a way that Pascal constructs do not. Even those Pascal implementations that provide separately compiled units such as the UCSD (University of California at San Diego) p-System do not provide for truly modular development.

Our focus here, however, is not Modula-2's underlying design concepts. Instead, we want to examine some of the flaws of Pascal, to see how Modula-2 solves them, and also to show how working Pascal programmers get around these flaws. In addition, our analysis should help you form some opinions on the value of the Modula-2 compensations for some of Pascal's design flaws.

Pascal's Seven Deadly Sins

We will examine seven separate problems with Pascal with different degrees of detail. Many of the solutions may be familiar to you, but you may find a useful Pascal trick or two that you haven't encountered elsewhere. While some of the problems are straightforward, others are more subtle and may call for more than one solution, each appropriate in a different programming context. For each language-design flaw, we present first the nature of the problem, then the approach taken in Modula-2, and finally one or more Pascal method for getting around the difficulty.

Short-Circuited Boolean Expression Evaluation

For processing a Boolean expression (e.g., in an IF statement), the Pascal-language definition does not permit what we call short-circuited evaluation—cessation of the evaluation when the expression is false. In fact, in most implementations, evaluation of a Boolean expression proceeds inexorably from left to right until the end of the expression. This can be inefficient, because the result of a Boolean expression can often be determined without a complete evaluation. Encountering a false part on one side of an AND expression means the result will be false, regardless of the complexity of the other side. For example, consider:

```
IF FALSE AND
   (
   (A=B) OR (B=C) OR (C=D) AND
   (ARCTAN(X*Z) / 99.0= 22.0)
   )
THEN DO_SOMETHING;
```

Clearly, the procedure DO_SOMETHING will never be invoked because of the false on the left side of the AND. In Pascal, the right side will be evaluated anyway, which is inefficient.

In the same manner, a true condition on one side of an OR expression

forces an expression to be true, regardless of the other side. In the statement below, DO_SOMETHING will always be called:

```
IF TRUE OR
  (
  (A=B) OR (B=C) OR (C=D) AND
  (X*2/ 99.0= 22)
  )
THEN DO_SOMETHING;
```

In addition to being inefficient, full Boolean evaluation causes problems when part of the expression is undefined. For example, suppose you wish to see if someone struck the Escape key. You might use the following code:

```
READLN(STRNG);            {STRNG is
                     declared STRING}
IF STRNG[1]=CHR(27)       {Escape is
                            ASCII 27}
THEN WRITE('Escape was
detected!');
```

This works fine, unless the user hits Return without entering anything. In such a case, the variable STRNG has a length of zero and that causes a value-range error for the IF statement. In Modula-2, this problem is easily avoided with the following test for the length of the string:

```
IF ( LENGTH(STRNG)<>0) AND
  ( STRNG [1]=CHR (27) )
THEN WRITESTRING('Escape was
  detected!');
```

If the first part of the IF expression, LENGTH(STRNG)< >0, is found to be false, then the evaluation is short-circuited, and the second conjunct is never evaluated. This prevents a reference to STRNG[1] that produces an error.

If you attempt such an approach in UCSD Pascal, you will discover, to your dismay, that the compiler generates code that blindly evaluates the entire expression. Even when the first part is false, the second conjunct will be evaluated, despite the fact that "FALSE AND X" must always be false, regardless of the value of X. In this Escape-detection example, the Pascal code still produces a value-range error.

One well-known substitute for AND expressions in Pascal is to use two IF statements as below:

```
IF ( LENGTH(STRNG)<>0 ) THEN
  IF ( STRNG[1]=CHR(27) ) THEN
    WRITE('Escape was detected!');
```

If the first IF is false, then the second IF will not be evaluated. Thus, for AND-type expressions, the Pascal programmer can simulate a short-circuited evaluation of the Boolean expression.

Short-circuited evaluation works equally well with OR conjuncts in Modula-2. In Pascal it is necessary to

If you attempt such an approach in UCSD Pascal, you will discover, to your dismay, that the compiler generates code that blindly evaluates the entire expression.

find a way to replace the OR expression with nested IF statements in order to prevent the unwanted evaluation of its second part. If the first conjunct is true, there is no need to evaluate the second, since the entire expression must be true.

Suppose you want to call procedure WHATEVER if the user either types the Escape key followed by the Return key, or if just "Return" is entered. In Modula-2, short-circuiting makes the following statement a good solution:

```
IF (LENGTH(STRNG)=0)
OR (STRNG[1]=CHR(27))
THEN WHATEVER;
```

In Pascal, to accomplish the same result, code like this must be used:

```
IF LENGTH(STRNG)=0
THEN WHATEVER
ELSE IF STRNG[1]=CHR(27)
THEN WHATEVER;
```

Here, the second conjunct is the IF expression of the IF statement embedded in the IF statement of the first conjunct. A match for either IF expression results in WHATEVER, but the second IF expression is evaluated only if the first is false.

To get the same results provided by the short-circuited evaluation of expressions in Modula-2, you have to put forth more effort in Pascal and the end result is not as readable.

Machine-level Access

One of the goals of high-level languages is to avoid machine-dependent code. Machine-independent programs are both more portable and more reliable than machine-dependent programs. Of course, in the real world you often find yourself forced to access actual machine addresses, or call subroutines contained in ROM (read-only memory) at some machine address. Since machine independence is a fundamental principle of Pascal, the language has no explicit way to access machine addresses, as BASIC does with PEEK and POKE.

In Modula-2, the standard data-type ADDRESS is provided to enable access to particular locations in memory. ADDRESS is defined as a pointer to a word, so it is machine-dependent—word size is, after all, a machine-dependent quality. Suppose that a variable SOMEADDR is defined as an address and assigned a particular address value. An operation like PEEK can be performed simply by looking at the value of the word pointed to by SOMEADDR:

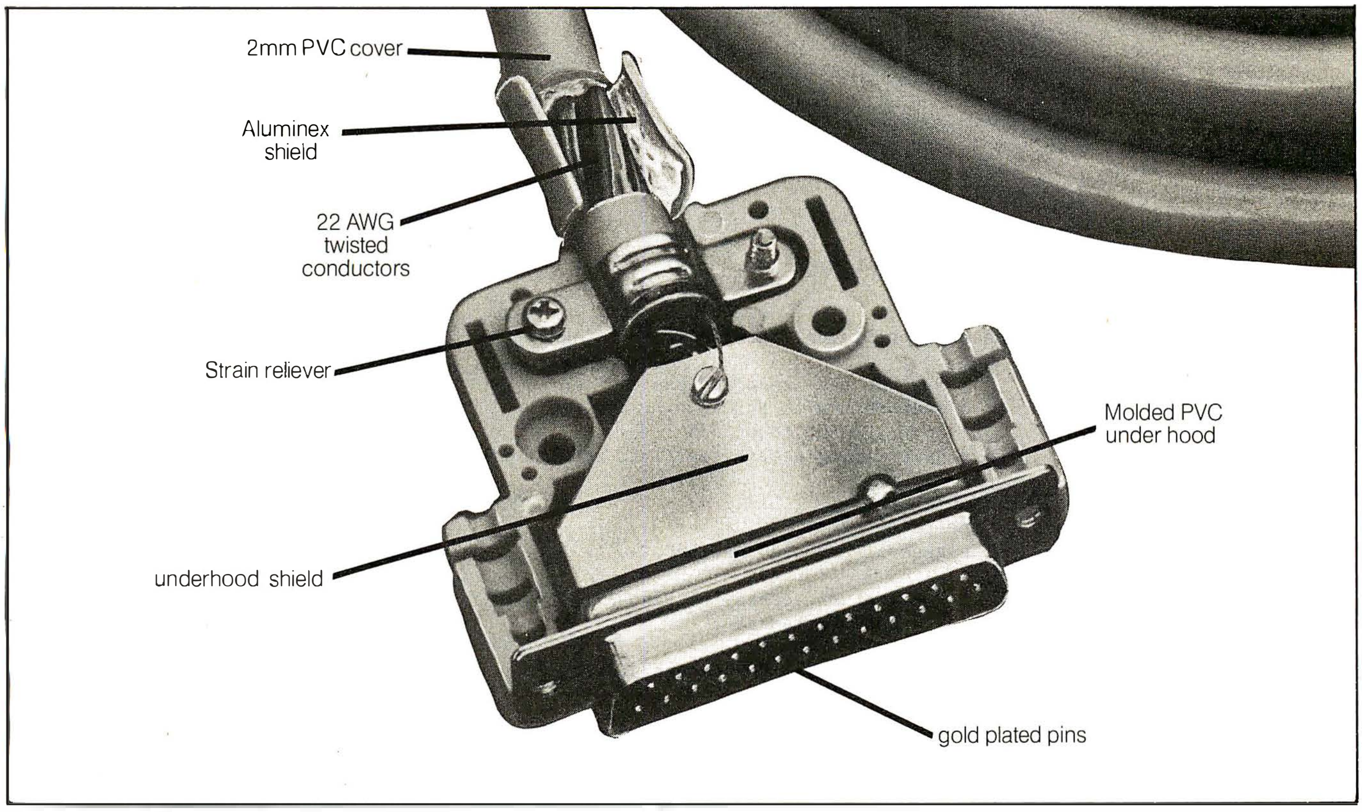
```
SOMEWORD := SOMEADDR ^;
```

To perform the equivalent of a POKE statement, you simply assign an address to a variable of the ADDRESS type and then assign a word to the location pointed to by the address:

```
SOMEADDR := 28990;
SOMEADDR ^:= SOMEWORD;
```

The ADDRESS data type permits the assignment of cardinal values—those between zero and MaxCardinal—directly to its variables.

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Listing 1: *Calling a machine-language program in ROM from an assembly-language procedure designed to be linked to Pascal as an EXTERNAL procedure.*

```
{Pascal program which calls a routine at C005 Hexidecimal}
PROGRAM trycall;

 PROCEDURE CALL(LOCATION: INTEGER); EXTERNAL;

 BEGIN
 CALL(-15104); {-15104=C500Hex address of ROM in slot 5}
 END.


Below is the external assembly procedure which calls a routine
at the address passed to it.

        .MACRO POP      ;Stores 1 word off stack
        PLA
        STA     %1
        PLA
        STA     %1+1
        .ENDM

        .MACRO PUSH     ;Loads 1 word onto stack
        LDA     %1+1
        PHA
        LDA     %1
        PHA
        .ENDM


        .PROC CALL,1    ; {procedure call(addr: integer)}

CALLADDR .EQU   0               ; must be page zero address
        POP     RETURN          ; save return to PASCAL
        POP     CALLADDR        ; save ADDRESS to be JSR
        JSR     @CALLADDR       ; jump saving return (call) to address in
                                ; CALLADDR
        ;do any other special stuff here
        ;that may be needed before return to
        ;pascal, if this is not a general-purpose "caller".

        PUSH    RETURN          ; Push return address to Pascal
        RTS                     ; Now back to Pascal

RETURN  .WORD                   ; Temporary area for return address
        .END
```

Modula-2 implementations may optionally provide a facility to specify a fixed address for a variable when it is declared. This feature has the following form:

VAR KEYBOARDSTATUS [28990]:
CARDINAL;

Another example of machine-level access is provided in the Volition Systems' implementations of Modula-2 that permits the use of CODE procedures. A CODE procedure's body consists of a sequence of machine-code instructions and operands. Because a p-machine approach is used in these implementations, such a procedure consists of p-code instructions rather than the machine instructions of the actual central processing unit. This means that such CODE procedures can give access only to the pseudomachine; it would be interesting to see this capability in a native machine implementation of Modula-2.

Standard Pascal provides no direct means for achieving low-level machine access. Fortunately, there are ways around the problem. A pointer variable in Pascal—as in Modula-2—is a variable that can access actual machine addresses. Suppose we want to PEEK address 23120. We could declare a variable such as IPTR to be an^ INTEGER (pointer to an integer). If we could make the assignment

IPTR: =23120,

we could print the value contained in that location with the statement

WRITELN('Value at address 23120
is=', IPTR ^); .

The catch here is that strong type checking in Pascal forbids the assignment of 23120 (an INTEGER type) to IPTR (an^ INTEGER). Using variant records, however, you can define two types of elements that share the same memory location. Define one of the elements to be an INTEGER and the other to be a POINTER to an INTEGER:

```
TRICK: RECORD CASE BOOLEAN OF
          TRUE: ( I: INTEGER );
          FALSE:( IPTR: ^ INTEGER );
       END;
```

Now, make the assignment

TRICK.I: = 23120;

Since TRICK.I and TRICK.IPTR share the same location in memory, we in fact have assigned 23120 to IPTR as well. Thus IPTR^ refers to the contents of 23120, the desired result.

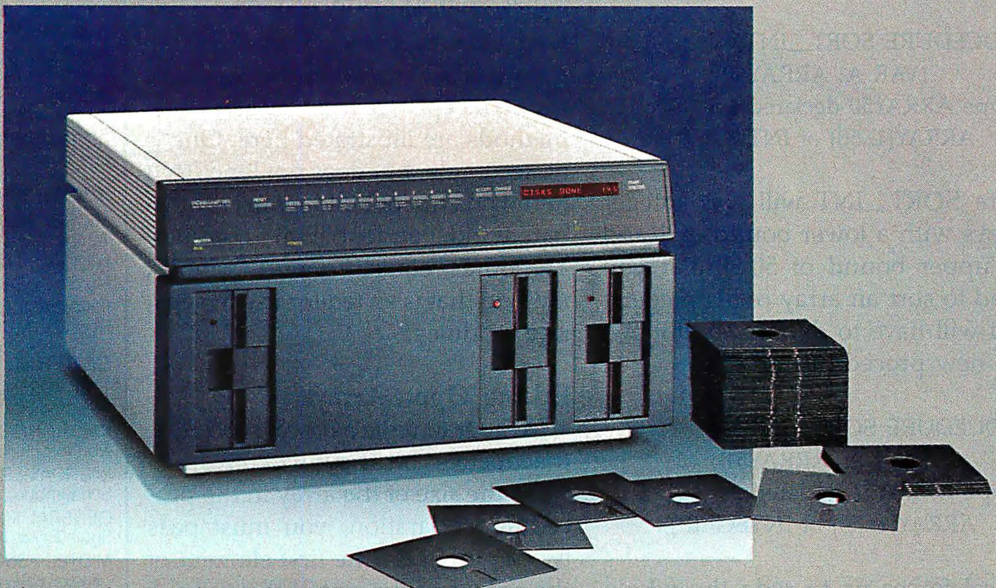
This technique lets us simulate PEEK and POKE statements in Pascal. But suppose we have a subroutine contained in a ROM that we wish to call. Pascal has no direct analog to the call to an address that BASIC provides. The UCSD implementations, however, make it possible to link an externally assembled subroutine to a Pascal program. Such an EXTERNAL assembly-language routine can actually perform the call to the ROM address. Figure 1 gives a sample program using this technique.

An option to include in-line native-code procedures would probably be more convenient in Pascal than separately linked assembled code, such as that in figure 1. But at least it is possible to use native code modules in Pascal implementations such as UCSD's.

Pascal Lacks Open Array Parameters

How many times have you, as a Pascal programmer, wished you could write a procedure or function that could take arrays of some base type as parameters without regard to the bounds of the array? Wouldn't it be nice to be able to write a single procedure that sorts an array of inte-

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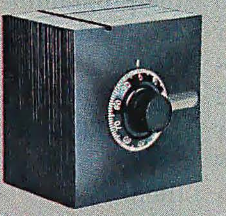
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gers into ascending order or that prints out an array of strings, no matter how many elements the array has?

If you write a procedure SORT_INT(A), that sorts an array of integers, your procedure declaration might begin:

```
PROCEDURE SORT_INT
          (VAR A: ARRAY50);
(*Type ARRAY50 declared as
     ARRAY[1..50] of INTEGER*);
```

Here SORT_INT will sort integer arrays with a lower bound of 1 and an upper bound of 50. But if you need to sort an array of 51 integers, you will have to declare the following new procedure:

```
PROCEDURE SORT_INT
          (VAR A: ARRAY51);
(*Type ARRAY51 declared as
     ARRAY[1..50] of INTEGER*);
```

Pascal forces us to redo the whole procedure we wrote for sorting 50 integers in order to sort an array of 51 integers.

This approach wastes programmer time and computer memory. It also discourages the writing of modular code for use in more than one program. It would be better if we could write a procedure that sorts integer arrays of any length, place it in a system library, and retrieve it for use in later programs. Without this capability, programmers are forced to write special-purpose code each time an integer array of different length is to be sorted. There are also the attendant risks of error that otherwise would not be present if a well-tested library module could be used for the same purpose.

Modula-2 permits the use of open array parameters. An open array parameter is one that specifies the base type of the array (INTEGER, in the case of the proposed SORT_INT procedure) without constraining the bounds of the array. In Modula-2, the opening of the SORT_INT declaration could be

```
     PROCEDURE SORT_INT
  (VAR A: ARRAY OF INTEGER);
```

Whatever the upper and lower bounds of the actual array parameter passed to SORT_INT, within the procedure they will be considered to be 0..HIGH(A), where HIGH(A) is the number of elements in the array.

As much as a Pascal programmer might wish for open arrays, they aren't available in Pascal. There are ways, however, to get some of the advantages of the Modula-2 open array concept within Pascal. Two methods are illustrated here. One is quite simple, but does not lend itself to the practice of building user-transparent independent library modules. The other requires a more complex method that is suited for use in separate modules.

Faking Open Arrays

In order to write a Pascal procedure that operates on arrays without specifying the size of the array in the procedure declaration, you must pass two arguments—the first element of the array and the size of the array. A trick must be employed to access other elements of the array, given the first element.

The simple method requires that the programmer using the sort procedure define a variant record.

```
     TYPE SINGLE_ELEMENT:
     ARRAY [1..1] OF INTEGER;
```

then:

```
VAR INTVARIANT: RECORD CASE
          INTEGER OF
    0:    (I_ARRAY: ARRAY[1..50] OF
          INTEGER);
    1:    (I_ELEMENT: SINGLE_
          ELEMENT);
END;
```

INTVARIANT is a variant record that can contain either an array of fifty integers or a single element array. The two variants of INTVARIANT, I_ARRAY and I_ELEMENT, share the same location in memory. Now we can pass I_ELEMENT to the sort procedure in order to get at the elements of I_ARRAY.

Within the sort procedure you must turn off range checking in order to refer to elements outside the

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Listing 2: *A program demonstrating calls to a general sort module depending on a user-supplied interface mechanism. To use the sorting procedure PASC_INT_SORT to sort a different array of integers, a separate variant declaration, similar to that of INVARIANT, is required.*

```
PROGRAM VAR_ARRAY_DEMO;

  TYPE SINGLE_ELEMENT  =  ARRAY[1..1] OF INTEGER;

  VAR INTVARIANT: RECORD CASE INTEGER OF
            0: (   I_ARRAY:   ARRAY[1..50] OF INTEGER); (*actual array*)
            1: ( I_ELEMENT: SINGLE_ELEMENT); (*to satisfy Pascal*)
            END;

      I: INTEGER;

  PROCEDURE PASC_SORT_INT (VAR ITEM: SINGLE_ELEMENT; ARRAYSIZE: INTEGER);
  (* This procedure sorts an array of integers by increasing value,
     using a selection sort technique.  *)
    VAR I,J,TEMP: INTEGER;
    BEGIN
    (*$R-  must turn off range checking *)
    FOR I:=1 TO ARRAYSIZE-1 DO
      FOR J:=I+1 TO ARRAYSIZE DO
       IF ITEM[J] < ITEM[I] THEN
          (*ITEM[J] smallest so far. Exchange w/ ITEM[I]*)
          BEGIN
          TEMP:=    ITEM[I];    (*save element I in temp*)
          ITEM[I]:= ITEM[J]; (*put element J into element I*)
          ITEM[J]:= TEMP;    (*put temp into element J*)
          END;
    (*$R+ may turn range checking back on*)
    END; (*PASC_SORT_INT*)


BEGIN (*MAIN*)
  FOR I:=50 DOWNTO 1 DO INTVARIANT.I_ARRAY[I]:=50-I+1;
  WRITELN('Sorting array I_ARRAY. Please wait...');
  PASC_SORT_INT(INTVARIANT.I_ELEMENT, 50);
          .
          .
          .
END. (*MAIN*)
```

bounds of the variant passed, I_ELEMENT. For example, the procedure PASC_SORT_INT shown in listing 2 turns off range checking so that it is possible to refer to elements of I_ELEMENT, even though I_ELEMENT is only a single element array. In the body of PASC_SORT_INT, ARRAYSIZE is used to check that the upper boundary of the actual array is not exceeded. (In Modula-2, a separate size parameter need not be passed, since the standard procedure HIGH( ) is used to return the upper bound of an array.)

This method is quite easy to implement. Unfortunately, it requires that the programmer consciously engage in variant record trickery every time the general procedure for sorting integers is to be used. Every time, you've got to declare the array to be sorted, not as a straightforward array, but rather as a variant record, with one variant the actual array to be sorted. Is there a way to imitate open arrays in Pascal without having to make a variant record declaration global to the call of the sort procedure?

Invisible Open Array Trickery

There is a somewhat more complicated approach that conducts its dirty work invisibly to the calling program or procedure. With this technique, an independent library module such as that given in listing 3 simulates PEEK and POKE statements to place values in the array. You do not have to be aware of the variant record tricks to use this library unit.

The success of the invisible approach to imitating open arrays depends on the version of Pascal employed for the program. As it happens, in the UCSD Pascal Version II.0 implementation (and its offspring, Apple Pascal), the address of the leftmost VAR parameter of a procedure is placed in the memory location immediately before the location re-

Text continued on page 382

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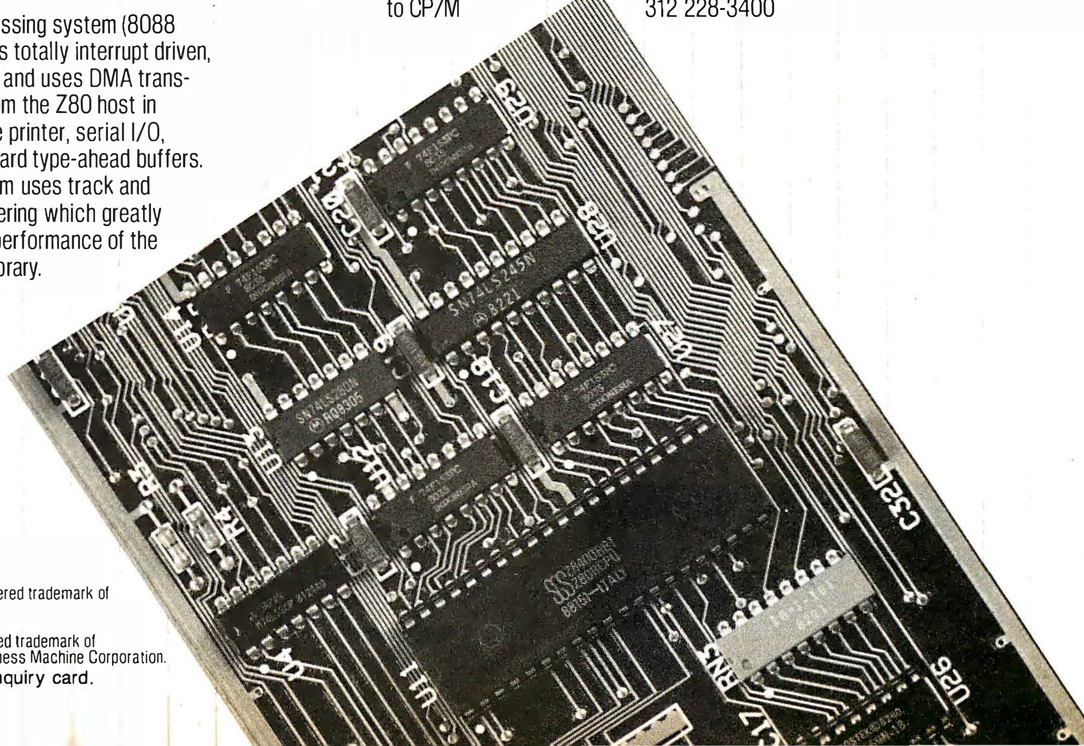
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Listing 3: *A module for sorting integers that does not require knowledge of the variant record tricks outside of the actual sorting unit. The client modules need not provide special record formats for the arrays to be sorted. This method is likely to prove more implementation-dependent, however, than that in listing 2.*

```
(*$S+*)
UNIT SORT_UNIT;

INTERFACE (*procedure defined here is callable by a program*)
PROCEDURE SORT_INT (VAR INT: INTEGER; ARRAYSIZE: INTEGER);

IMPLEMENTATION (*code below is not accessable to any calling program*)

PROCEDURE PUT_ITEM(VAR FIRST: INTEGER; WHICH_ITEM: INTEGER;
                       VALUE : INTEGER);
(*order of declaration of parameters is important!*)
(*FIRST must be first parameter*)

(*PLACE_HOLDER MUST be first declared variable. This ensures that
             address of 'FIRST' is at X[-1]*)
VAR PLACE_HOLDER: ARRAY[0..0] OF INTEGER;
(*VARIANT lets us "peek" at elements of array*)
   VARIANT: RECORD CASE INTEGER OF
              0: (     PTR: ^INTEGER);
              1: (ADDRESS:  INTEGER);
            END; (*CASE*)
   BEGIN
     (*$R-*)
     (*put location of 'name' into 'address'*)
     VARIANT.ADDRESS := PLACE_HOLDER[ -1 ];
     (*$R+*)
     (*bump address to access desired element *)
     VARIANT.ADDRESS := VARIANT.ADDRESS
                   + (WHICH_ITEM-1) * SIZEOF (FIRST);
     VARIANT.PTR^:=VALUE;
   END; (*PUT_ITEM*)

(*this procedure reads the value of an element of the array*)
FUNCTION GET_ITEM(VAR FIRST: INTEGER; WHICH_ITEM: INTEGER):INTEGER;

                        (*order of declaration of parameters is important!*)
                        (*FIRST must be first parameter*)

    (*PLACE_HOLDER MUST be first declared variable. This ensures that
    address of 'FIRST' is at X[-1]*)
VAR PLACE_HOLDER: ARRAY[0..0] OF INTEGER;
(*VARIANT lets us "peek" at elements of array*)
   VARIANT: RECORD CASE INTEGER OF
              0: (     PTR: ^INTEGER);
              1: (ADDRESS:  INTEGER);
            END; (*CASE*)
   BEGIN
     (*$R-*)
     (*put location of 'FIRST' into 'address'*)
     VARIANT.ADDRESS := PLACE_HOLDER[ -1 ];
     (*$R+*)
     (*bump address to access desired element *)
    VARIANT.ADDRESS := VARIANT.ADDRESS
                  + (WHICH_ITEM-1) * SIZEOF (FIRST);
    GET_ITEM:= VARIANT.PTR^
  END; (*GET_ITEM*)

PROCEDURE SORT_INT (* VAR INT: INTEGER; ARRAYSIZE: INTEGER *);
(* This procedure sorts an array of integers by increasing value,
   using a selection sort technique.  *)
  VAR I,J,TEMP: INTEGER;
  BEGIN
  FOR I:=1 TO ARRAYSIZE-1 DO
    FOR J:=I+1 TO ARRAYSIZE DO
     IF GET_ITEM(INT,J)<GET_ITEM(INT,I) THEN
        (*INT[J] smallest so far. Exchange w/ INT[I]*)
        BEGIN
        TEMP:= GET_ITEM(INT,I);                 (*save element I in temp*)
        PUT_ITEM(  INT,I, GET_ITEM(INT,J)  );   (*put element J into element I*)
        PUT_ITEM(  INT,J,  TEMP  );             (*put temp into element J*)
        END;
  END; (*SORT_INT*)

BEGIN
END. (*SORT_UNIT*)
```

Text continued from page 378:

served for the first local variable. Using a subscript one less than the defined range of the local array makes it possible to access the memory location containing the address of the VAR parameter. Each successive memory location for the other elements of the array can then be calculated, starting from this address.

This method, like the first, uses the variant record technique, this time to accomplish direct memory manipulation, through simulated PEEKs and POKEs. The article by Daniel Sokol in the September 1980 BYTE ("Notes on Absolute Location Interfaces to Apple," page 324) discusses simulating PEEKs and POKEs in Pascal.

Constant Expressions

Whenever constants must be used, it is good practice to assign names to them. This increases readability and makes program changes easier. For example, suppose you wish to have several arrays of different types, each having the same maximum size. By defining a constant

```
CONST ARRAYSIZE = 20;,
```

you can change the size of the following arrays:

```
VAR X: ARRAY[1..ARRAYSIZE] OF
         INTEGER;
    Y: ARRAY[1..ARRAYSIZE] OF
         CHAR;
    Z: ARRAY[1..ARRAYSIZE] OF
         REAL;
```

just by changing the constant ARRAYSIZE.

In Pascal, constants cannot be expressions. This greatly limits the usefulness of the CONST definition. For example, suppose array Y must have limits twice the size of X, while Z must be three times the size of X. Pascal requires that the three upper bounds' constants be declared in a manner that makes their inherent relation invisible. In Modula-2, the relation among the three constants can be made clear in a declaration with the form:

```
CONST XSIZE = 20;
      TWICEX = XSIZE * 2;
```



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```
        THRICEX = XSIZE * 3;

VAR X: ARRAY[1..XSIZE] OF
          INTEGER;
    Y: ARRAY[1..TWICEX] OF
          CHAR;
    Z: ARRAY[1..THRICEX] OF
          REAL;
```

Using this Modula-2 code, to increase the array sizes only requires a change of the single constant XSIZE, and the other arrays change accordingly. In Pascal, the best that we can do is to use constant identifiers that clarify their intended relation, as in:

```
CONST XSIZE = 20;
      TWICEX = 40;
      THRICEX = 60;
```

You have to hope that, if you must later modify the program by doubling the size of the arrays, the names TWICEX and THRICEX will help you to remember to change those constants as well as XSIZE.

Another problem with Pascal is in defining character constants. Suppose we wish to define ESCAPE as ASCII (American National Standard Code for Information Interchange) character 27. Pascal doesn't allow the expression

```
CONST ESCAPE = CHR(27).
```

In Modula-2, however, this declaration can be accomplished with

```
CONST ESCAPE = 33C
```

which declares that ESCAPE is a character constant with the octal value 33 (decimal 27).

The traditional Pascal programmer's solution to the prohibition of constant expressions is to use global variables as constants. A special initialization procedure is created that assigns to global variables the values that should remain constant throughout the program. The declaration of ESCAPE in Pascal is done like this:

```
CONST ESC_ORD = 27;
VAR   ESCAPE: CHAR;
        •
        •
```

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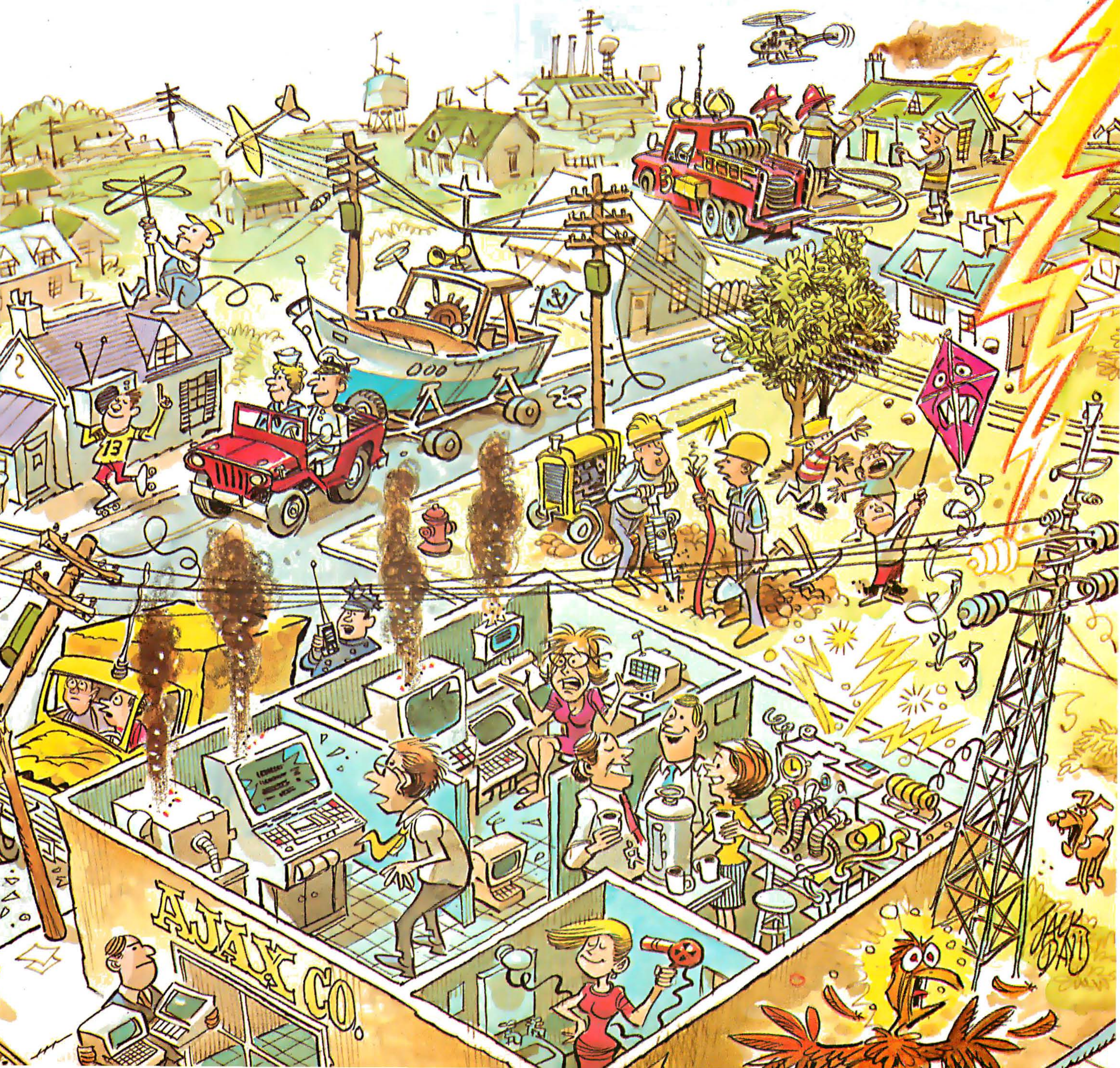
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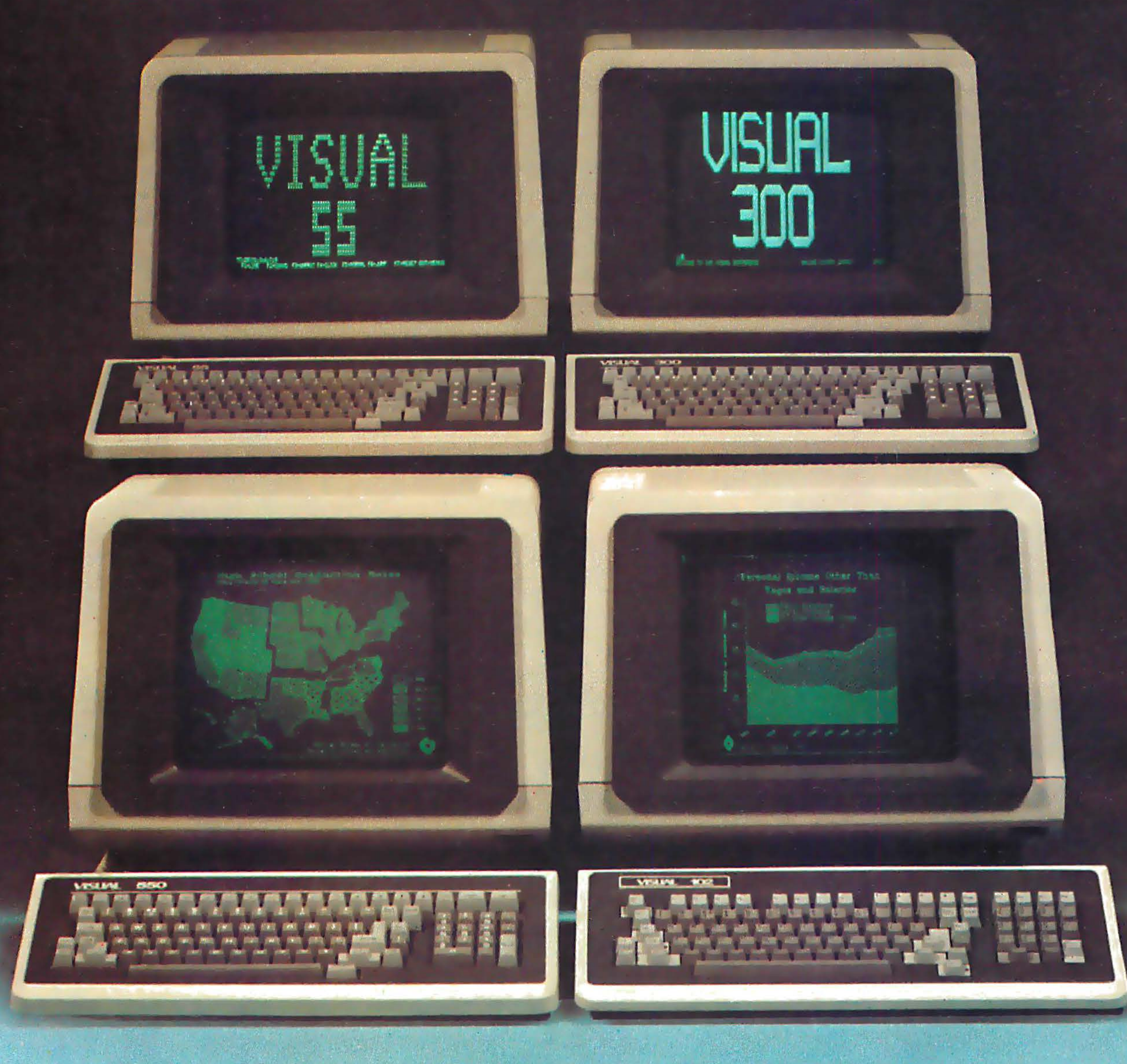
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```
PROCEDURE INIT;
BEGIN
  ESCAPE := CHR(ESC_ORD);
            •
            •
END;            (*INIT*)
```

This approach is much less desirable than the use of true constants, since the value of a global variable could be inadvertently changed by any procedure in the program. To increase the probability of program correctness, adopt a special naming convention for global variables that masquerade as constants (e.g., ESC_CONST for ESCAPE) to reduce the chances of accidentally assigning values to them outside of the initialization procedure.

Restricted Declaration Order

In Pascal, all the declarations at a particular program level must be made in a particular order: first all the constant declarations, then the types, next variables, and finally procedures and functions. This strict constraint is likely to reduce program readability in some contexts, because it prevents grouping together of related declarations. In Modula-2, one can group related constant, type, and variable declarations for improved readability, as in:

```
(* 8-bit declarations *)
CONST MAXBYTE = 255;
          ZERO = 0;
TYPE BYTE = [ZERO..MAXBYTE];
VAR ABYTE, BBYTE: BYTE;

(* 12-bit declarations *)
CONST MAXTWELVEBIT = MAXBYTE
                       * 16 + 15;
TYPE TWELVEBIT =
         [ZERO..MAXTWELVEBIT];
VAR ATWELVE, BTWELVE: TWELVEBIT;
```

There is no simple fix for Pascal's restrictions on declaration order. To some extent, the problem can be reduced by avoiding global constant and type declarations where only local ones are required. Such a practice promotes natural groupings. At times, however, Pascal programs must include long sequences of constant declarations followed by sequences of type and variable declarations, whose correspondence can only be determined by careful reading of the declarations and the judicious use of comments.

One method that Pascal programmers use to make relationships clear among constants, types, and variables is to make use of descriptive names. If the names of related elements contain the same meaningful elements (such as the declarations of the TWELVEBIT family illustrated above), the consequences of restrictions on declaration order can be partially overcome. But this brings up another problem with many Pascal implementations, that of restricted identifier lengths. Although the Pascal language definition puts no restrictions on the names of identifiers, many implementations are restricted to eight significant characters. The only patch for this limitation is to make certain that your identifiers differ in the first eight characters. This can be done quite easily, but it often results in cryptic acronyms and abbreviations that are not easy to interpret. Unfortunately, there is no simple solution to this problem.

CASE Limitations

The CASE statement is a very useful feature of Pascal. With it, we can perform one of a group of statements depending on the value of the CASE selection variable. For example, consider:

```
CASE A OF
1: WRITE('ONE');
2: WRITE('TWO');
3: WRITE('THREE');
END;
```

Here, we conveniently can print out the written equivalent of an integer. But what if A does not have the value one, two, or three? In standard Pascal, the result is not even defined. Fortunately, in Apple Pascal (and other UCSD Pascal successors) the CASE statement is defined to fall through this event. We can add a statement following CASE such as:

```
IF NOT ( A IN [1..3] ) THEN
WRITE('A OUT OF RANGE');
```

Modula-2 provides a more elegant solution, permitting us to specify explicitly *within* the CASE statement an ELSE clause to be executed if none of the case labels are matched. Some recent Pascal implementations also provide such a special selector, sometimes called OTHERWISE.

Pascal requires that every label of the CASE statement must be enumerated. Suppose A can be 1 to 999. In Modula-2 we can use the following CASE statement:

```
CASE A OF
  1..9      : WRITESTRING('Less
               than 10 '):
  10..99    : WRITESTRING('Greater
               than 9, but less than 100'):
  100..999  : WRITESTRING('Greater
               than 99, but less than 1000')
  ELSE        BOUNDSERROR
END;
```

This statement is clearly much more readable than the equivalent Pascal statement, in which every label, including all those from 100 to 999, would have to be listed (100, 101, 102, 103, 104, etc., all the way to 998, 999:).

Because Pascal does not allow subranges as CASE selectors, programmers do not use the Pascal CASE statement for this type of programming. Instead, nested IF statements perform the same task:

```
IF A > 0
THEN
  IF A < 10
  THEN WRITE ('Less than 10')
  ELSE
    IF A < 100
    THEN WRITE ('Greater than 9, but
      less than 100')
    ELSE
      IF A < 1000
      THEN WRITE ('Greater than 99,
        but less than 1000')
      ELSE BOUNDSERROR
ELSE BOUNDERROR;
```

This code is less readable than that using CASE selectors, although it may produce more efficient code.

Static Variables

In Pascal, variables that are local to

a procedure are always allocated dynamically. That is, room for them is allocated automatically on entry to the procedure. When the procedure is exited, the memory used by the local variables is freed up for other use. While this is a useful feature because it saves memory, it can be a problem if the values must be retained between invocations of the procedure.

The easiest solution available to the Pascal programmer is to declare the variables in an outer block. The values of the variables will be retained as long as the block in which they are declared is not exited. But this means variables that really ought to be invisible outside of the procedure must be made global, and therefore visible, to the rest of the program. As global variables, they are vulnerable to modification by parts of the program that should have no knowledge of them.

In Modula-2, it is possible to declare a variable for use in procedures in such a way that its value is preserved across invocations of the procedure—as though the variable is global—while preventing any other part of the program from accessing it. To do this, one declares a module, providing a visibility barrier around the procedure. Suppose we want to count the invocations of a procedure DOSTUFF. The count variable, COUNTDOSTUFF, can be made inaccessible to the rest of the program if it and DOSTUFF are declared inside a module, STUFFMODULE, as follows:

```
MODULE STUFFMODULE;
EXPORT DOSTUFF;
  VAR COUNTDOSTUFF: CARDINAL;
  PROCEDURE DOSTUFF
  (I: INTEGER);
    VAR A,B,C: INTEGER;
  BEGIN
    COUNTDOSTUFF :=
            COUNTDOSTUFF + 1;
    .
    .
  END;     (*DoStuff*)
BEGIN      (*StuffModule's body*)
  COUNTDOSTUFF := 0;
END;       (*StuffModule*)
```

If STUFFMODULE is declared at the top level, that is, just within the program module, then its body, which initializes the variable COUNTDOSTUFF, will be executed at the time that the program body is executed. The DOSTUFF procedure, which has been explicitly exported from the module, is available from everywhere else in the program, but its count variable, COUNTDOSTUFF, is inaccessible from outside the procedure DOSTUFF. COUNTDOSTUFF is a global variable in the sense that it exists outside of the procedure DOSTUFF, but it is a local variable in terms of its visibility outside of the procedure. UCSD Pascal also permits this feature of hidden variables that can retain their values in the unit construct. Those variables declared in the implementation portion of the unit, rather than in the interface, are present at the level of the unit, but are invisible to program entities outside the unit.

Switch or Fight

Our purpose here has not been to present Modula-2 as a panacea for all of Pascal's faults. In some ways Modula-2 makes life harder for the Pascal programmer. For example, consider the lack of a set of type-insensitive I/O (input/output) procedures, such as Pascal's WRITE and WRITELN. In Modula-2 you cannot mix types in a WRITELN statement. Instead, you must use a separate procedure to output each type, such as use WRITESTRING for strings and WRITEREAL for reals. Furthermore, each write procedure can have only a single parameter.

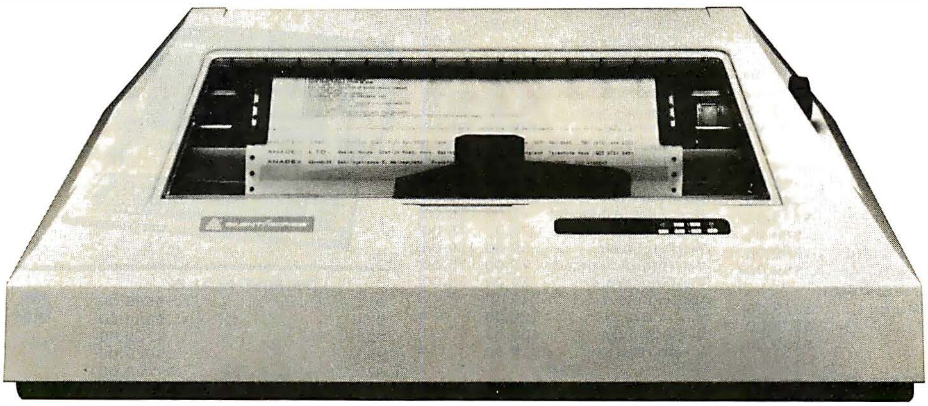
Like Pascal, Modula-2 is not without faults. Both are well designed, but each has features that at least some programmers will object to.■

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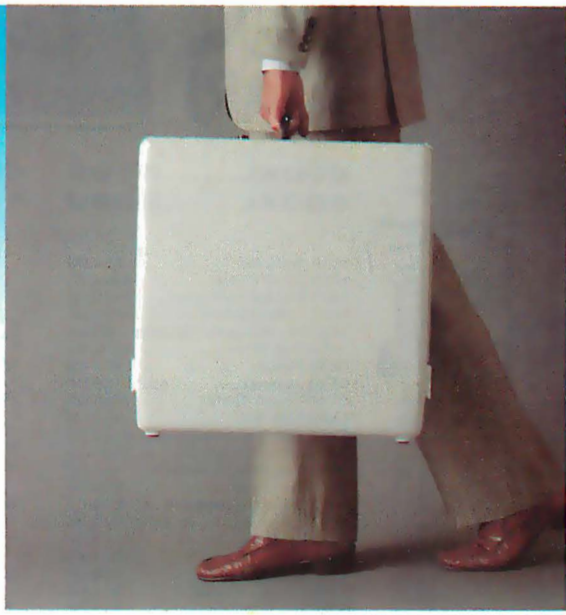
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Trademarking Software Packages

Trademark clearance can prevent litigation and loss of hard-earned goodwill.

by Robert Greene Sterne and Perry J. Saidman

The scene is all too familiar. The developer of a successful software package sits in the office of a trademark attorney fretting. He holds in his hand a certified letter he received the day before from another lawyer whose client is challenging his use of the brand name Aisle for his software package.

The letter states that the client owns a federal trademark registration for use of the name Isle on software and that he considers the use of Isle and Aisle for the same type of product likely to cause confusion in the marketplace. In addition, the letter warns that the developer "immediately cease and desist from using the Aisle trademark on his software packages" or be subjected to dire legal consequences.

The letter has made the developer furious. He can't believe that he has been forced to waste time with what he considers legal harassment when he should be working on his new advertising campaign, handling a dissatisfied customer, or taking care of other pressing business concerns that need his attention. But he decides to take the bull by the horns and deal with the matter because the letter says that he must respond within 30 days. He has brought the Aisle package to the marketplace, so he hopes he can take a tough position against the owner of the Isle trademark with the help of his lawyer.

A clearance search determines whether a word chosen as a trademark is already being used.

Choosing a Trademark

The developer's lawyer asks him to recount how he developed the Aisle package and how he chose its name. The software entrepreneur knows that the time it takes to tell his story will cost him a lot of money in legal fees, but he enjoys describing the history of his creation.

The story is really very simple. In early 1981, the developer saw a need and met it with his Aisle software package. Some of his friends who own computers discovered his useful program and asked for copies, which he provided proudly and gladly. He later decided that he could sell such a package and started analyzing ads in computer magazines for marketing tips. Studying how they were written and designed, he noticed the symbols that appeared with their names: ©, ™, and ®.

He also learned that he must come up with a name for his program by which it could be distinguished from competing programs. Everywhere he looked he saw successful software packages with great names such as Visicalc, Wordstar, and Easy Writer. He finally settled on Aisle after considering many names. When he discussed his choice with his closest friends, they responded enthusiastically. He did not know of anyone else using the name Aisle for the type of software he produced, therefore he began to market the package under that name. A friend advised him to use an ® beside the Aisle name in all of his ads.

The lawyer interrupts the story to ask whether a clearance search of the Aisle mark had been conducted to determine whether anyone was

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using the name on software. The developer says he is unfamiliar with the term clearance search but that he had never consulted a lawyer about the name. In addition, he says, he was unaware of the Isle trademark when he adopted the name Aisle. After he learned of Isle's existence, he also discovered that its sales are confined exclusively to the East Coast, while Aisle software is sold primarily on the West Coast. Becoming agitated, he points out that Aisle differs significantly from Isle. The lawyer calms him, then explains some principles of trademark law.

Trademarks Afford Protection

The major issue in most trademark-infringement suits, the lawyer notes, is whether the plaintiff's and defendant's trademarks, used on their respective goods, will likely cause confusion as to the goods' source or origin. Thus, he explains, even if two names differ, a court could find likelihood of confusion in the event the sound, appearance, and meaning of the two are close. In the developer's case, he says, even though the meanings differ, the appearance of the words Isle and Aisle is very similar and the sound is identical. He concludes that a court could therefore find a likelihood of confusion to exist.

The developer objects to the idea that the two words might cause confusion, saying that he did not know of any instance where a customer bought Aisle software thinking it was an Isle package. His lawyer points out, however, that it was the likelihood of confusion that constituted the legal test, not the actual confusion; the fact that no one had ever confused the two programs did not matter.

The lawyer goes on to explain that both the Aisle and Isle marks are arbitrary choices for names of software packages. Under trademark law, arbitrary means that the product's name does not describe its goods—in this case Isle and Aisle do not describe the function of the packages they name. Software, after all, is neither an island nor a lane. The lawyer offers an example to illustrate the point.

The primary meaning of the word "apple" is a type of fruit. Thus, the use of the word "apple" on any type of goods other than fruit, such as Apple bicycles, Apple sportscoats, or Apple computers, is an arbitrary use. Other examples of products with arbitrary trademarks include the Lisa computer, Camel cigarettes, and Dove soap. Arbitrary trademarks, he explains, tend to be strong trademarks that are protectable as soon as they are adopted. In other words, no customer recognition has to be developed through sales to protect them,

Adopting a new name will constitute trademark infringement if customers are likely to be confused as to source or origin.

in contrast to primarily descriptive, surname, or geographic trademarks, which do require customer recognition for protection.

A descriptive name is one that describes a function, property, or characteristic of the goods it labels. An example is Sortfile Plus, used for a software package that sorts files quickly and efficiently. Franklin is a surname used as a trademark for a personal computer, and an example of a geographic trademark is Palo Alto, used on a spreadsheet package. To afford protection, these types of trademarks require customer recognition. Because of their original meaning to the public, a secondary meaning must attach in the market through certain commercial activity. This secondary meaning is an indication of source for the trademarked goods. In other words, the Franklin or Palo Alto must be recognized by the interested public as symbols of computer goods from a particular source before they can be protected.

In the case of the Isle versus Aisle trademarks, the lawyer points out that they are both arbitrary names used for the same type of software,

and therefore are likely to cause confusion. Consequently, the critical legal questions would involve priority and good-faith adoption in a remote geographic area. The general rule in trademark law is that the user who first applies a trademark to goods in a particular geographic area has exclusive rights to it and related products in that area. The law allows another user to use the same or a similar trademark for the same goods only if the second user has adopted, and first used, his trademark in good faith in a geographic area remote from the first user. This legal defense would be available to the Aisle developer under normal circumstances, the lawyer says, because the developer of Aisle was unaware of the Isle trademark when he chose the name Aisle and because he was selling Aisle software in an area remote from that where Isle was sold.

However, the lawyer notes ruefully that the owner of the Isle trademark was smart to take the initiative to obtain a federal registration of Isle. The Isle developer was granted such protection a few months before Aisle's developer adopted a similar name. The federal registration provided nationwide constructive notice of the Isle trademark, which means that the law will presume people have notice of the trademark. Thus its owner can presume others are aware of its use, and the developer's defense of good-faith adoption is eliminated.

Arbitrary trademarks, such as Apple computers, don't describe the function of the products or services they identify.

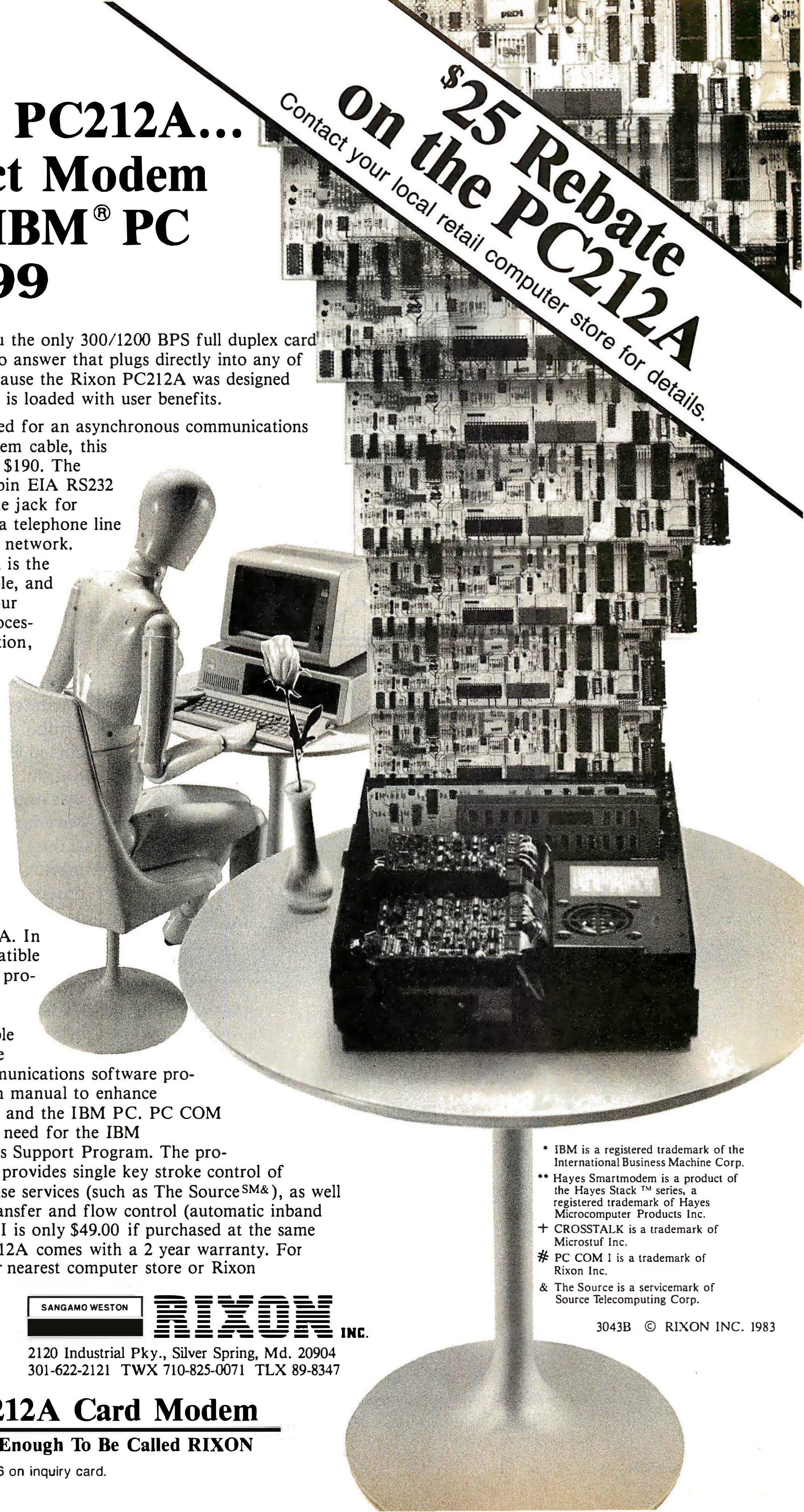
The developer does not believe what he is hearing. He asks the lawyer pointedly whether the law was telling him to stop using the Aisle mark. The lawyer says that without a legal fight, the law was saying just that. The developer explodes, vowing that he will not be party to such legal ransom by the owner of the Isle trademark, particularly now that his software package is known extensively by the Aisle name. He says he will refuse to change the name unless a court orders him to, and the meeting comes to an end.

Epilogue

Despite his lawyer's warning, the developer did not respond to the letter, and several months later he was served with a summons in a lawsuit. After spending $30,000 in the defense of a preliminary injunction motion, the case was settled as follows: even though he still felt he had done nothing wrong, the developer agreed to stop using the Aisle mark on his package or "any confusingly similar variation thereof"; to destroy all labels, ads, promotional materials, and actual packages using the Aisle mark; and to pay court costs. Nevertheless, the developer disregarded the court order and subsequently was found to be in contempt of court, which resulted in a stiff fine, addi-

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Clearly, the developer did not handle this in a proper legal manner or cost-effectively. He could have maintained the hard-earned goodwill his trademark had won by taking a few steps to protect it.

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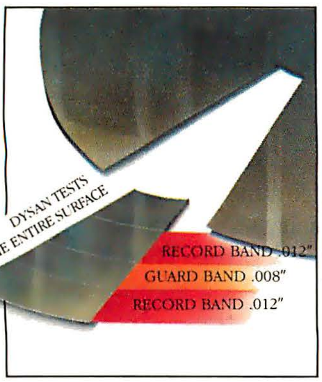
Robert Greene Sterne is a partner in the law firm Saidman, Sterne & Kessler (412 Barr Building, 910 Seventeenth St. NW, Washington, DC 20006), specializing in computer and intellectual property law. He is co-chairman of the APLA 1984 National Institute on Computer Law and author of Trademark Law: Federal, Maryland Statutory and Maryland Common Law.

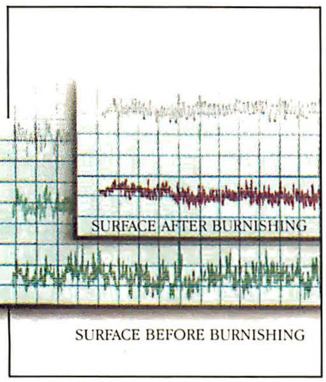
Perry J. Saidman is also a partner in the firm Saidman, Sterne & Kessler. A member of the United States Trademark Association, he teaches a patent bar review course sponsored by the Patent Resources Group and is author of Patent Law for General Practitioners and Business Lawyers.

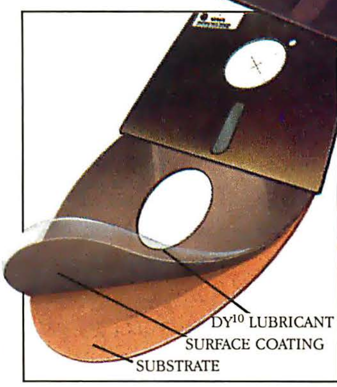
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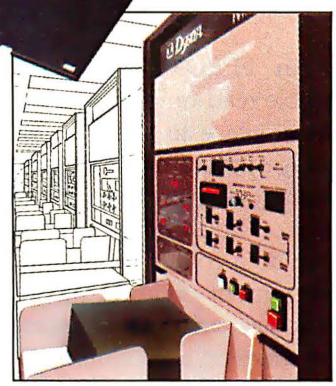
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An EPROM Simulator

This versatile project includes battery backup

by Albert S. Woodhull

An EPROM (erasable programmable read-only memory) is a convenient place to store a machine-language program (for instance, a bootstrap loader program for a large system or the entire application program in a data-collection system). The development cycle for such programs involves writing and assembling the program on a development computer system and programming (burning) an EPROM. The EPROM is then plugged into its socket on the target computer system and the program is tested.

EPROMs are great for programs that are already debugged, but they create a bottleneck in the development process. On my development system, the EPROM programmer takes up memory space needed by the editor I use for writing programs, so I have to power down and change the hardware configuration before programming the EPROM. And, of course, once a program is in EPROM it cannot be easily changed, so I can't use a monitor or debugger on the target computer to try out simple modifications at the machine-language level. A bug requires going back to the development system. I have often wished for something simpler.

There are several alternatives to EPROMs. Steve Ciarcia has written about the new electrically erasable nonvolatile memory chips in the December 1979 BYTE ("Add Nonvolatile Memory to Your Computer," page 36). These devices are an attractive possibility, but they are expensive and cannot be plugged into the same socket as an EPROM. Eric Rehnke described an EPROM emulator in the February 1982 BYTE ("Build an EPROM Emulator," page 194). This two-port memory gives a development system the ability to control the contents of a portion of the memory of a target system. While this approach is excellent for some purposes, I needed nonvolatile memory for development of bootstrap programs for the development system itself. I chose a third approach, a battery-powered RAM (random-access read/write memory) that could be unplugged from one socket and plugged into another without risk to chips or loss of data.

The EPROM simulator turned out to be an easy project. I decided to use a 2K-byte wide static-memory chip, the Hitachi 6116. I have been using these in my projects and for main memory in my development system. Standard 2716 EPROMs can be used in the same sockets, a convenient arrangement for frequent changes of hardware configuration. The 6116 uses CMOS (complementary metal-oxide semiconductor) technology and requires very little power when deselected. By proper choice of operating conditions, the standby current drain of one of these chips can be held to less than 2 mA (milliamperes). CMOS chips also are relatively tolerant of voltage variations. Hitachi's data sheets specify the operating voltage of the 6116 as 5.0 volts ± 10 percent; many digital integrated circuits require ± 5 percent regulation. As I will explain later, the voltage tolerance for retention of data is more permissive than the operating voltage range.

Nicad (nickel-cadmium) rechargeable batteries are an obvious choice for powering the EPROM simulator. The *nominal* voltage of a nicad cell is 1.2 volts, but when fully charged, a battery of four cells will produce just over 5.5 volts. Nicad voltage holds up well during discharge; a 4.5-volt endpoint enables use of most of the charge. Size AA nicad cells are readily available and are rated at 450 milliampere-hours (mAh), enough to keep a 6116 chip alive for well over a week.

After choosing to power a 6116 RAM with nicad batteries, the problem I had to deal with next was protecting the memory chip and its data from damage while unplugging it from the development system and plugging it into the target computer. Plugging and unplugging solid-state components while power is applied is not a good idea. Pins won't make connections simultaneously and internal voltages momentarily can be the wrong polarity. Even if you could be sure components would survive the surges of power, there is too much chance of misalignment or short circuit with a large number of closely spaced connections. The answer to this is to use buffer circuits from which the power can be removed without turning off the RAM itself. Only inactive devices will be connected to the external plug during insertion or withdrawal. The buffer chips do not have to draw on the battery; they are needed only when power is available from a host development or target system.

The Circuit

The block diagram in figure 1 depicts the overall scheme. All connections to the 6116 RAM chip are isolated by tristate buffers. The buffer chips get their power from the host computer; the RAM is powered by a 5-volt battery. A diode allows the battery to be partially recharged from the computer but prevents the buffers from draining the battery when the host computer is off or the unit is unplugged. The diode also permits the RAM to get its operating current from the host when it is selected. During a read or write cycle, a selected RAM chip may need as much as 80 mA. The buffers for the address and control lines are always enabled; the data buffers are selected appropriately when the socket into which the simulator is plugged is selected for reading or writing.

Details of the circuit are shown in figure 2. Instead of conventional OR gates, I put an extra 74LS367 buffer chip on the board and used two buffer sections and pull-up resistors to gate the enable signals for the data buffers. I was planning for the future—someday I'll want to use 4K- or 8K-byte RAM and EPROM chips, and unused buffers then can be wired up for additional address lines. The switches on the $\overline{CS}$ and $\overline{W}$ lines are for peace of mind. The $\overline{CS}$ switch guarantees that no transients will come through when the buffers are powered up or down; the $\overline{W}$ switch protects the RAM from accidentally

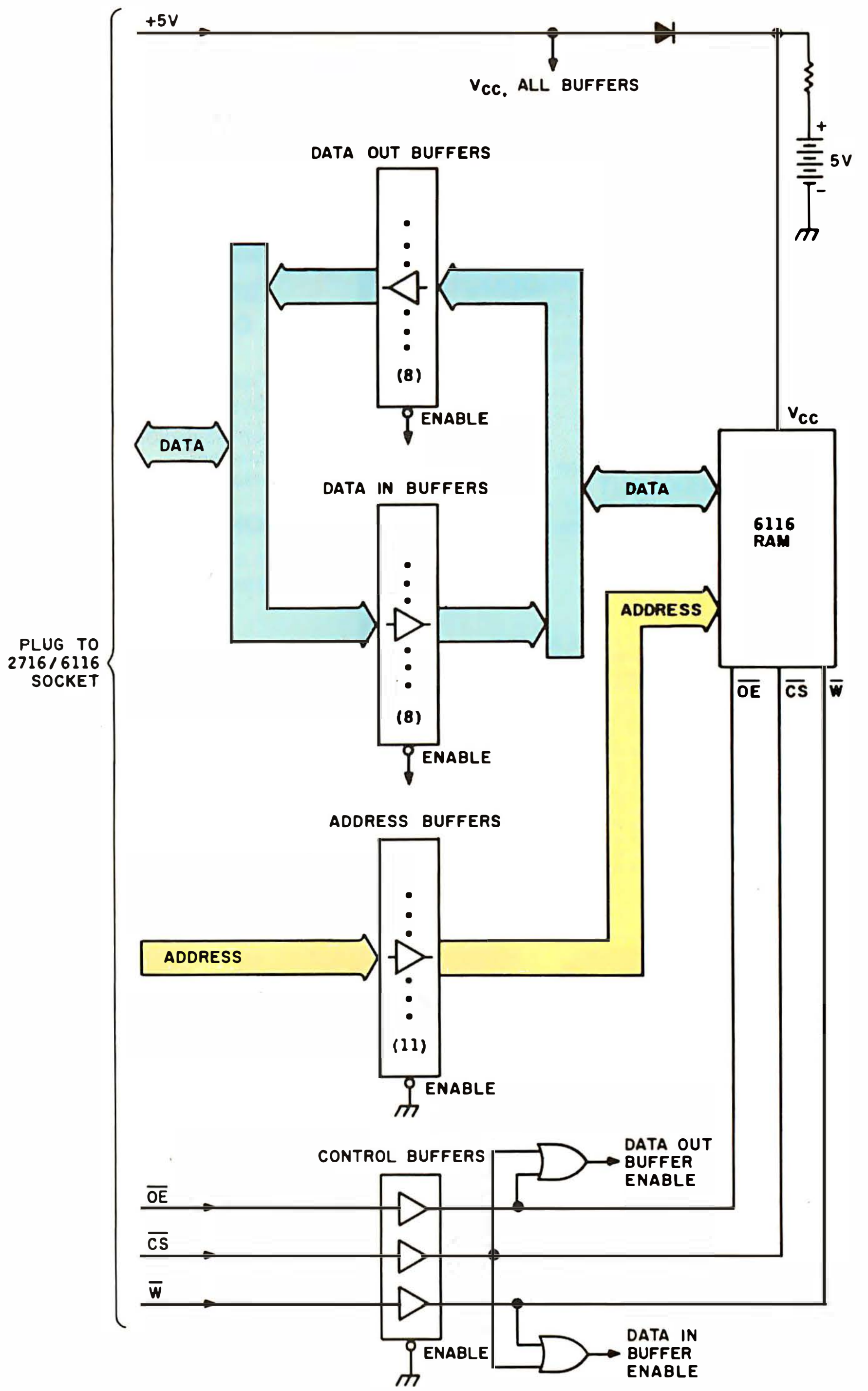


Figure 1: *A block diagram of the EPROM simulator. All external connections go to a 24-pin DIP (dual-inline package) plug that can be inserted into a 2716 EPROM or 6116 RAM socket on the host computer. The host may be either the development system upon which a program is being written and assembled or a target system upon which the program will be run. All lines from the host are isolated from the RAM by 74LS367 buffers, and these buffers receive power from the host. The RAM is powered by a battery. The host may be powered down and the EPROM simulator removed to be plugged into an alternative host or a different host memory location, without damage to the RAM chip or loss of data.*

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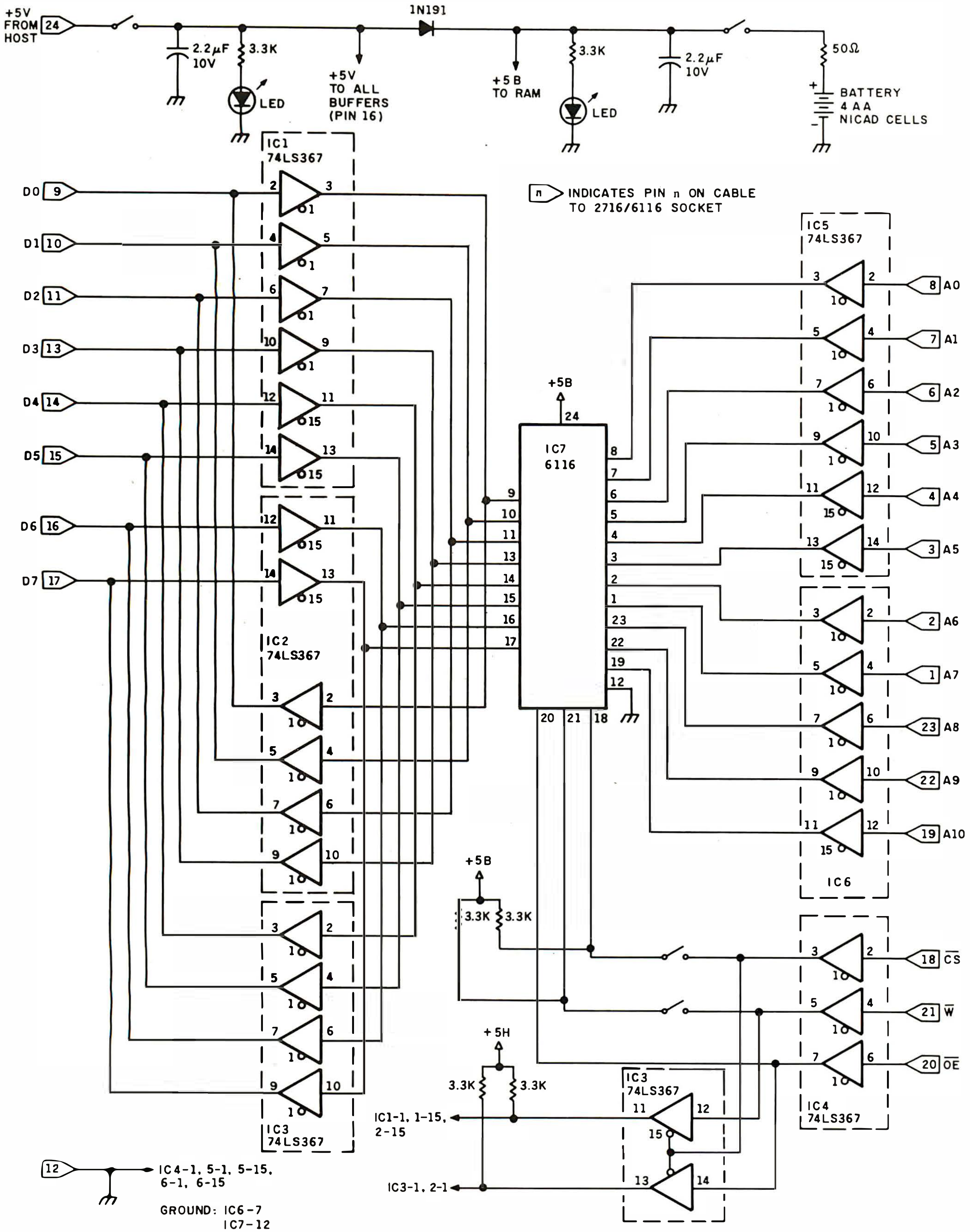


Figure 2: *A detailed schematic diagram of the EPROM simulator. The pin numbers indicate the pinout of the plug that connects to a 2716 or 6116 socket on a host computer, other numbers indicate pin connections on the integrated circuits. For clarity, the enable lines to the buffers (six 74LS367s) are not shown; the connections are summarized at the bottom of the diagram. The control lines with overbars are active low lines, i.e., a zero-volt level on line $\overline{CS}$ selects the RAM chip. Two sections of IC3, a 74LS367, are used as OR gates; because the output is high impedance when the buffers are not enabled, pull-up resistors are needed. Note that these pull-up resistors connect to the host-derived power, +5H, but the pull-up resistors on the control lines to the RAM chip must be connected to the battery line, +5B.*

being written into. Both of these lines have pull-up resistors connected to the battery supply to ensure that the chip will be in the standby mode when the host power is off or disconnected.

The diode is a germanium type; this is not essential, but it reduces the diode voltage drop to about 0.25 volt. The 50-ohm resistor limits the charging rate of the battery and protects the diode from surges of current. The standby current demand of the RAM is so low that the voltage drop through this resistor during discharge is unimportant. The LEDs (light-emitting diodes) are frills, but I like to know when a circuit is enabled. The one on the battery-powered side of the circuit probably draws as much current as the RAM, and can be omitted if data retention for long periods is necessary.

Construction

My prototype was constructed on a small piece of perforated board using wire-wrap techniques; there is nothing critical about the wiring, with the possible exception of the cable to the RAM or EPROM socket on the host computer. I made this cable about eight inches long with some doubts about whether it would give me problems. I've had no problems with an 8080 processor with a 500-nanosecond cycle, but a shorter cable might be necessary with a faster system. Mechanical protection is also needed; a wire-wrapped prototype board like this is something like a pet porcupine. To avoid short circuits on a crowded bench, I mounted the entire assembly inside a small plastic box.

Data Retention and Battery Charging

The maximum supply voltage for the 6116 is specified as 7.0 volts. This is a maximum safe-voltage rating, with no guarantee that the part will actually work while the voltage is that high. The operating voltage range specification of 4.5 to 5.5 volts is for all phases of operation, including writing and reading data. In the EPROM simulator, reading and writing only take place while the host

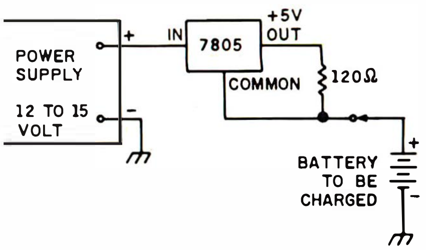


Figure 3: *A constant-current circuit for charging nicad batteries. The regulator maintains 5 volts across the resistor, which passes a current of about 45 mA. The resistor current and the small operating current of the regulator itself flow through the battery to be charged. The power supply may be rated at anything from 12 to 35 volts.*

computer supply is on; the diode will allow the battery voltage to be brought up if it is low. The voltage of a fully charged four-cell battery falls to 5.5 volts soon after the charger is disconnected. The rating sheets do not specify a supply voltage range for retention of data.

After constructing my EPROM simulator I experimented to try to determine these limits. With known data stored in the RAM, I charged the battery with an external charger, then checked and verified the data. Next, I loaded the battery with a resistor to discharge it to a low level and again checked the data. While charging at 45 mA, the battery voltage soared to about 6.3 volts, and during my discharge test I let the voltage fall to about 1.7 volts. The data remained intact in both cases. There is no guarantee that all 6116s will work this well, but it proved to me, at least, that retaining data with a battery is entirely feasible.

The battery cannot be fully charged from the host computer power supply with the circuit shown in figure 2. Diodes have a forward voltage drop that is relatively constant over a wide current range; with a germanium diode, this limits the voltage to which the battery can be charged to about 4.75 volts. If the EPROM simulator is constantly plugged into a computer that is used for a few hours each day, this should be good enough to retain data indefinitely, but an external charger will be needed if a full charge is required for maximum duration of data retention.

Standard nicads should be charged at about 10 percent of their Ah (ampere-hour) rating, requiring 14 hours for a full charge. A simple constant-current charger can be made with a standard voltage regulator chip and a resistor, as shown in figure 3. The regulator keeps the voltage across the resistor constant, which means the current through the resistor will be constant also. There is a small error due to the additional current that flows through the regulator's common terminal, but this is only a few milliamperes. The supply voltage must be greater than the fully charged battery voltage, plus the nominal output voltage of the regulator, plus about 2 volts. A 12-volt supply is adequate for charging the EPROM simulator battery, using a 5-volt regulator chip.

Using the EPROM Simulator

I'll describe the use of the EPROM simulator with an example. I gave it its first test by tracking down an annoying bug in my terminal I/O (input/output) routines, which normally are in EPROM where I can't modify them with the system debugger. I unplugged a RAM chip at a memory address I knew I would not need for my system routines, plugged the EPROM simulator into that socket, powered up, and copied the old system EPROM into the RAM with both the $\overline{\text{CS}}$ and $\overline{\text{W}}$ switches closed. I then opened both switches for protection, powered down the system, and replaced the system ROM with the EPROM simulator plug. With the $\overline{\text{CS}}$ switch on, everything worked as it had with the EPROM in place. Finally, I closed the switch in the $\overline{\text{W}}$ line and used the system debugger to quickly investigate several of the "what-if" questions I had about the program.

This EPROM simulator was a weekend project. By the next weekend I was wondering how I had lived without it. It makes any task involving development of code for an EPROM much more convenient. At the beginning of a project I know my programs will have bugs. Having my code as safe and portable as if it were in an EPROM, yet as easy to modify as if it were in RAM, makes starting such a project much more pleasant. ■

Albert S. Woodhull (33 Enfield Rd., RFD2, Pelham, MA 01002) has a Ph.D. in physiology and psychology and is an associate professor of computer studies and biology at Hampshire College in Amherst, MA. He uses computers for laboratory instrumentation in research in various aspects of physiology. His hobbies include ham radio operation, hiking, and backpacking.

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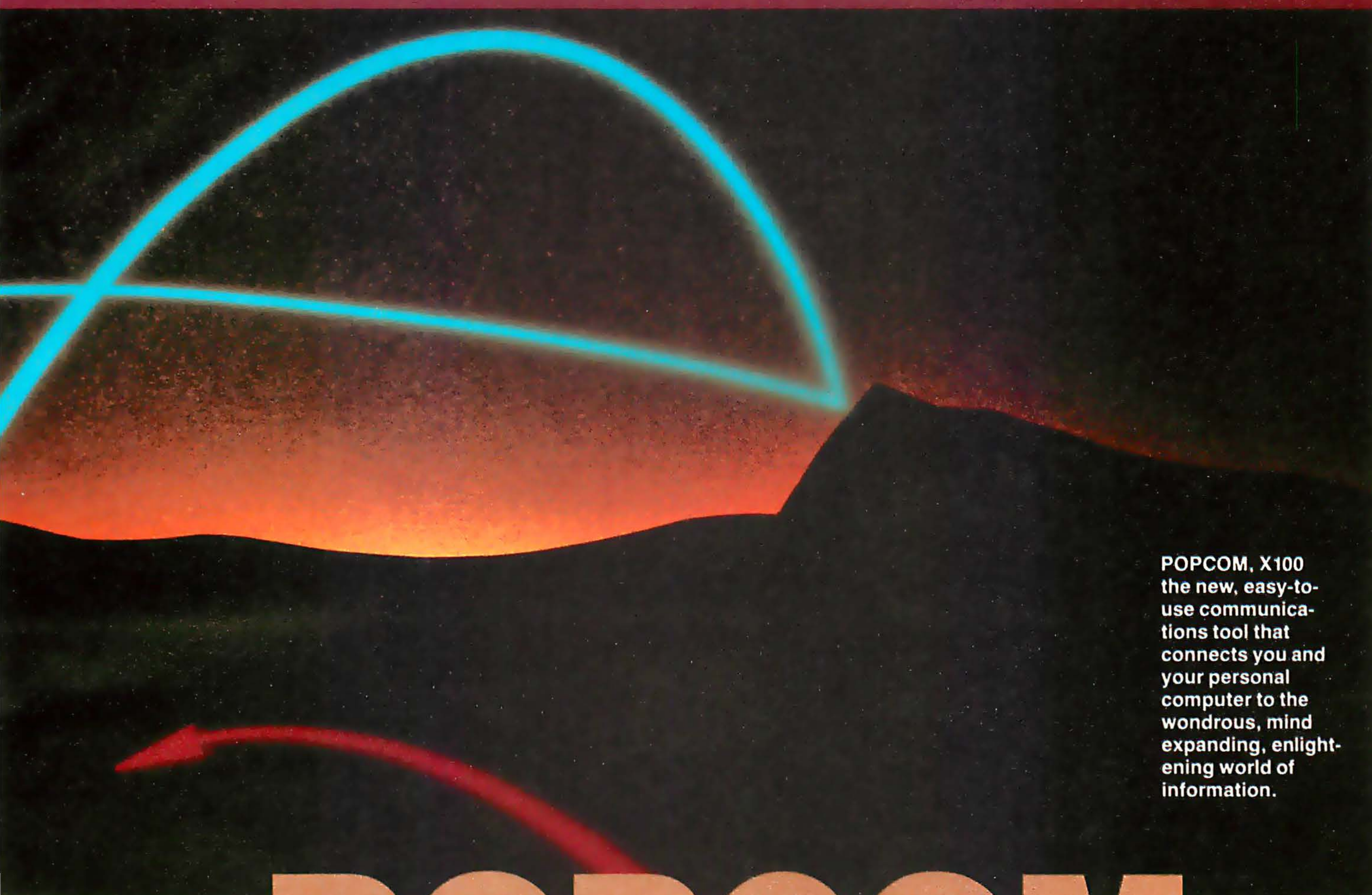
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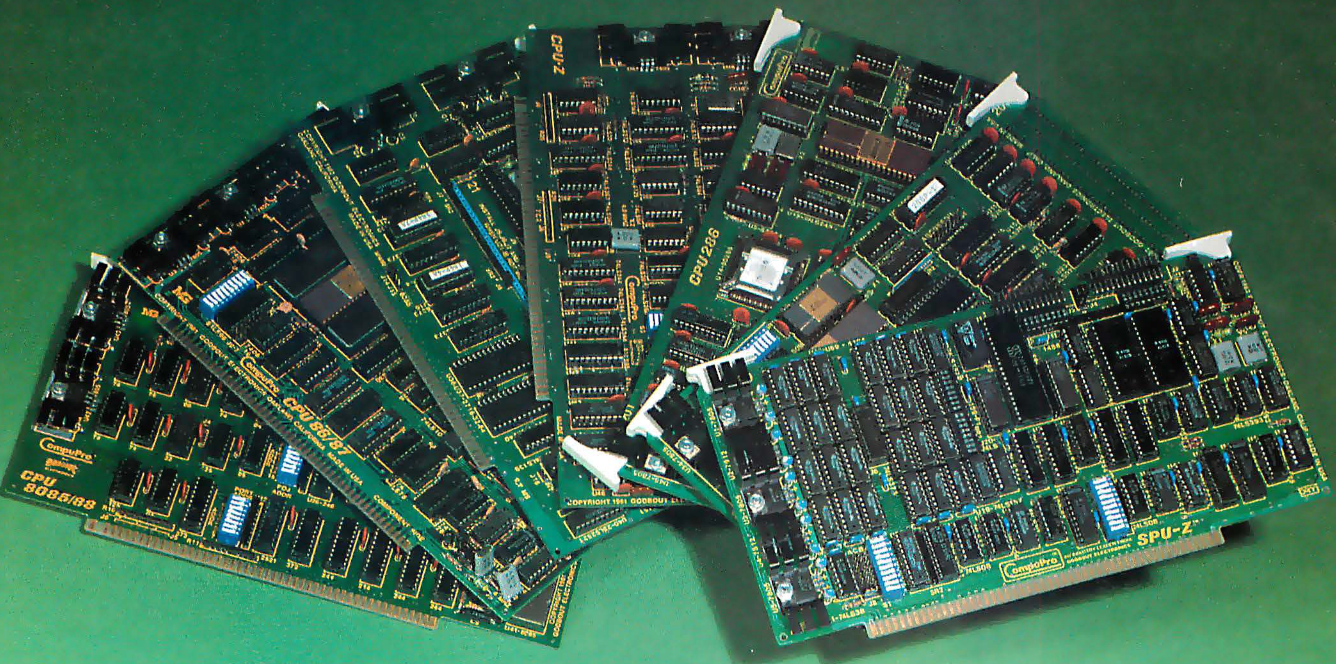
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Simulation with Electronic Spreadsheets

Spreadsheet programs make a career change

by Art Matheny

Electronic spreadsheets aren't just for financial models. In fact, they can simulate many different types of dynamic processes. In this article, I present examples of dynamic process simulation using Visicalc on an Apple II and Supercalc on an Osborne 1. I assume that you can also apply my examples to other electronic spreadsheet programs.

Using an electronic spreadsheet, you can construct a table with rows and columns of different kinds of entries. The entries may be character data (such as names or labels), numeric values, or formulas. Formulas usually contain references to other entries in the table. If a formula uses an entry that is also a formula, this question is raised: "Which formula is evaluated first?" Visicalc and Supercalc both start at the first row and first column, go down the first column to the bottom of the table, then to the top of the second column, down the second column, then to the top of the third column, and so on until the programs have calculated all the entries. Or you can tell them to calculate by rows instead of by columns.

Ambiguities may arise when one formula refers to another in one of two ways, a *forward* reference or a *circular* reference. A forward reference occurs when a formula refers to another formula that comes up later in the calculation sequence—further down the column or in any column further to the right. It is even worse if the second formula refers back to the first one, which is a circular reference. Figure 1 shows a spreadsheet with a circular reference. (The figures in this article use the notation of Supercalc.) Enter the formulas in cells A1 and B1 of figure 1 and recalculate the spreadsheet a few times.

With each recalculation, the numbers drift uncontrollably. You can, however, bring circular references under control. Figure 2 is an example of a useful circular reference. This spreadsheet calculates the balance of a savings account that is compounded monthly. The annual interest rate is entered in cell B2 and the monthly deposit in cell B1. Each time the spreadsheet is recalculated, a new month is computed. You can repeat the recalculations for as many months as you wish. To see how much money would be in the account after 20 years, press the recalculate key 240 times. Cell B3 keeps track of the number of months since the account was started. To reset to the starting condition, simply enter 0 in cell B1. Change the interest rate if you wish and then reenter the monthly deposit in cell B1.

The preceding example is an exact calculation for a savings account that is compounded monthly. The calculation is capable of being exact because the events that change the balance are discrete—that is, the time and interest payments change by fixed amounts that cannot be broken into smaller amounts. But dynamic processes are often continuous rather than discrete; that is, they may have no smallest discrete change because each change is infinitesimally small. Such processes are described by differential equations. The following differential equation describes the growth of population P with birth rate r:

$$dP = rPdt$$

The term dP refers to infinitesimal changes that occur in P as time (dt) changes infinitesimally.

A computer program can approximate the differential equation by using finite differences; thus,

$$dP \rightarrow \Delta P$$
$$dt \rightarrow \Delta t$$

The symbol Δ denotes a finite, rather than an infinitesimal, change in some

```
   |    A    ||    B    ||    C    ||    D    |
 1 |  1+B1       2*A1
 2 |
 3 |
 4 |
```

Figure 1: *A circular reference. A1 makes a forward reference to B1, and B1 refers back to A1.*

```
 |            A             ||        B        |
1|MONTHLY DEPOSIT            Ø
2|ANNUAL INTEREST RATE       .Ø8
3|NUMBER OF MONTHS           IF(B1=Ø,Ø,B3+1)
4|OLD BALANCE                IF(B1=Ø,Ø,B6)
5|INTEREST                   B2*B4/12
6|NEW BALANCE                B1+B4+B5
```

Figure 2: *Compound interest calculated using a circular reference.*

```
 |           A           ||          B          |
1|TIME STEP               Ø
2|TIME                    IF(B1=Ø,Ø,B2+B1)
3|-----------------------------------------
4|INITIAL POPULATION      1ØØ
5|BIRTH RATE              .1
6|OLD POPULATION          IF(B1=Ø,B4,B8)
7|BIRTHS                  B1*B5*B6
8|NEW POPULATION          B6+B7
```

Figure 3: *A spreadsheet simulation of a population explosion.*

quantity. The differential equation can then be approximated by a finite-difference equation:

$$\Delta P = rP\Delta t$$

or

$$P_1 = P_0 + rP_0\Delta t$$

where P_0 equals population at the start of Δt, and P_1 equals population at the end of Δt; thus, $P_1 - P_0 = \Delta P$.

The number of births during the time interval Δt is $rP_0\Delta t$. This equation can be used iteratively to simulate the population growth process. Given a starting population, the equation yields the population after a small time step, Δt. Starting from there, the equation can be used again for the next time step, and the next, and so on.

Figure 3 shows how to do this with an electronic spreadsheet. The formulas at B2 and at B6 contain IF functions. The IF function contains three arguments: the first is a condition and the other two are formulas. If the condition is true, the second argument is used; if the condition is false, the third argument is used. With the spreadsheet as shown, the condition is true in both cases. Thus, the time remains equal to 0, and the old population remains equal to the initial population. There is no change when the spreadsheet is recalculated. Move the cursor to B1 and save the table. It is now ready for use.

To begin the simulation, change the value at B1 to some value greater than 0 (1, for example). Now repeatedly press the ! key or whichever key produces a recalculation. Note that the value at B8 increases exponentially with time. If you continue until the time equals 100, the population should be well over 1 million. At this point, you may need to change column widths and formats to clean up the spreadsheet. To reset the system, just change the value at B1 back to 0.

The next example, figure 4, is more complex in that there are two quantities that vary with time. This model simulates the decay of nuclear isotopes. Suppose you start with 1000 micrograms of a certain radioactive isotope. Let's call this the parent isotope. Each parent nucleus eventually emits an alpha particle and thus decays into the daughter isotope. It is often the case that the daughter isotope is also radioactive. The daughter nucleus eventually decays into the final product.

Change the time step in B1 to 1 or any other positive value to start the simulation. The value in B8 is the amount of parent isotope that decays during each time step. Those nuclei are all converted into daughter nuclei, which is why B8 is added to the current daughter amount in cell C9. Notice that the daughter amount increases at first, reaches a maximum level, and then declines. A Geiger counter held up to this sample would measure the total activity of both isotopes combined.

You can experiment with different decay rates for the two isotopes by changing the values in cells B6 and C6. The decay rate is the probability that a given nucleus will decay in a unit of time. The half-life of an isotope equals the natural logarithm of 2 (ln2) divided by the decay rate. The time step used in B1 should be less than one-tenth of the shorter half-life.

When you set the time step in any of these examples, you should be aware of the trade-off between accuracy and number of iterations. If the time step is too large, the finite-difference approximation will need only a few iterations, but accuracy will be poor. If the time step is too small, the approximation will need many iterations, but accuracy will be

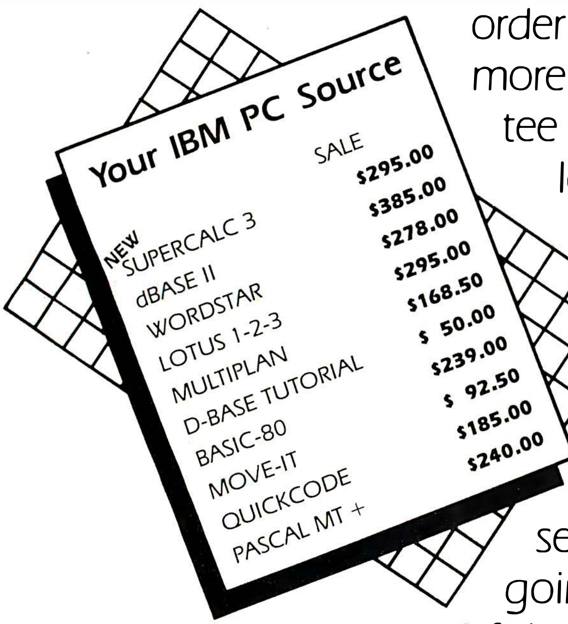
```
  |        A         ||        B         ||        C         |
 1|TIME STEP          Ø
 2|TIME               IF(B1=Ø,Ø,B2+B1)
 3|-----------------------------------------------------------
 4|ISOTOPE            PARENT               DAUGHTER
 5|INITIAL AMOUNT     1ØØØ                 Ø
 6|DECAY RATE         .Ø5                  .Ø2
 7|OLD AMOUNT         IF(B1=Ø,B5,B9)       IF(B1=Ø,C5,C9)
 8|AMOUNT OF DECAY    B1*B6*B7             B1*C6*C7
 9|NEW AMOUNT         B7-B8                C7+B8-C8
1Ø|-----------------------------------------------------------
11|TOTAL ACTIVITY                          (B6*B7)+(C6*C7)
12|LOG(ACTIVITY)                           LN(C11)
```

Figure 4: *A spreadsheet simulation of radioactive decay.*

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```
  |       A          ||        B        ||       C        |
 1|TIME STEP           0
 2|TIME                IF(B1=0,0,B2+B1)
 3|------------------------------------------------------
 4|SPECIES             PREDATOR           PREY
 5|INITIAL POP         50                 200
 6|BIRTH RATE          0                  0.3
 7|DEATH RATE          0.1                0
 8|INTERACTION         0.001              0.003
 9|OLD POPULATION      IF(B1=0,B5,B12)    IF(B1=0,C5,C12)
10|BIRTHS              B1*B8*B9*C12       B1*C6*C9
11|DEATHS              B1*B7*B9           B1*C8*C9*B12
12|NEW POPULATION      B9+B10-B11         C9+C10-C11
```

Figure 5: *A spreadsheet simulation of predator-prey interaction.*

very good. One way to judge the rate of error is to double the time step and compare the results.

The example in figure 5 is a finite-difference approximation of the Lotka-Volterra model of predator-prey interaction. When the prey population is high, the predators thrive and thus increase rapidly in number. As the predator population grows, however, the prey population declines because it has a difficult time surviving with all those predators around. Fewer prey means starvation for many of the predators, so the predator population falls. With fewer predators around, the prey are able to reestablish themselves in large numbers. Whether this cycle really occurs in nature is open to question, but the mathematics of this model are quite fascinating nevertheless.

The model assumes that if the prey were left alone they would experience unrestricted growth at the birth rate specified in cell C6. It also assumes that the predators have an intrinsic death rate, given in B7. The quantity in B8 is a measure of the skill of the predators in hunting prey, and the quantity in C8 is a measure of the probability that a prey individual will fail to escape an encounter with a predator. Using this simulation, you could construct a graph with the prey population on one axis and the predator population on the other. You could then follow the trajectory of this system for a complete cycle, modify the initial populations in B5 and C5, and draw other trajectories until a pattern emerges.

I have shown how spreadsheets can be used to model several dynamic systems. There are many other dynamic systems, discrete and continuous, that you can simulate with spreadsheets, which proves that spreadsheets can be used for much more than financial analysis. ■

Art Matheny earned an M.S. in physics at Purdue University. His hobbies are electronics and computer music. He can be reached at 1405 Four Seasons Blvd., Lutz, FL 33549.

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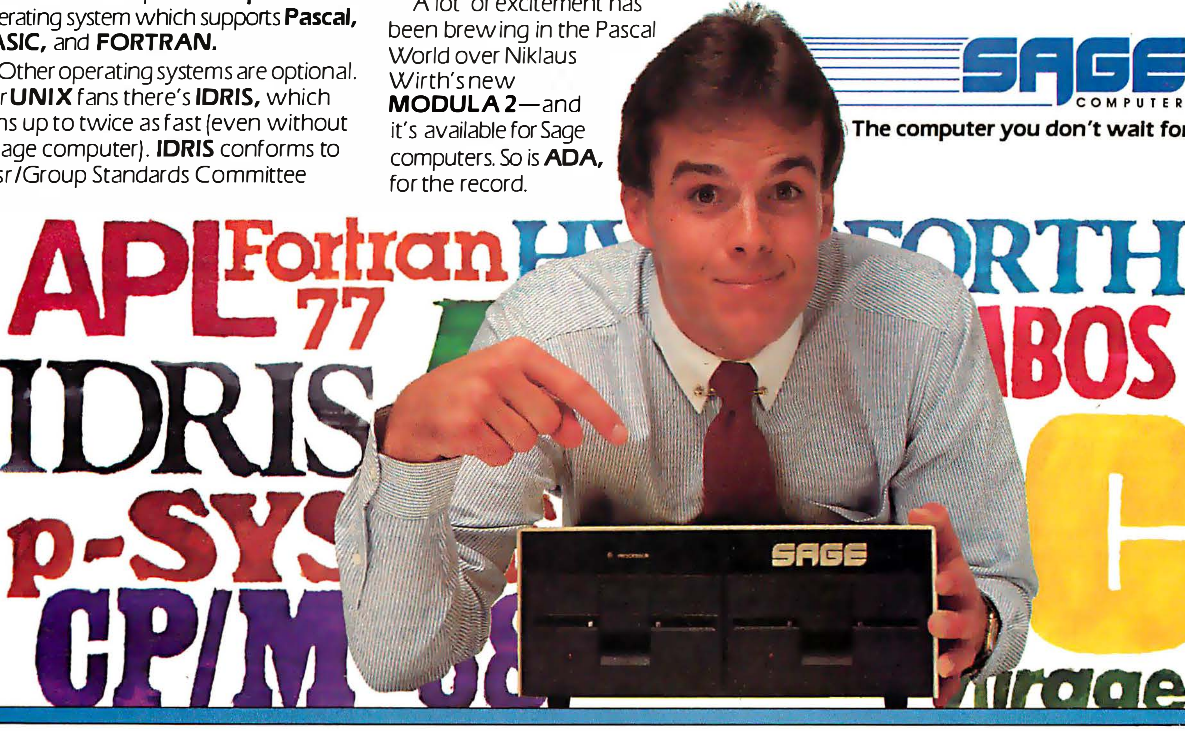
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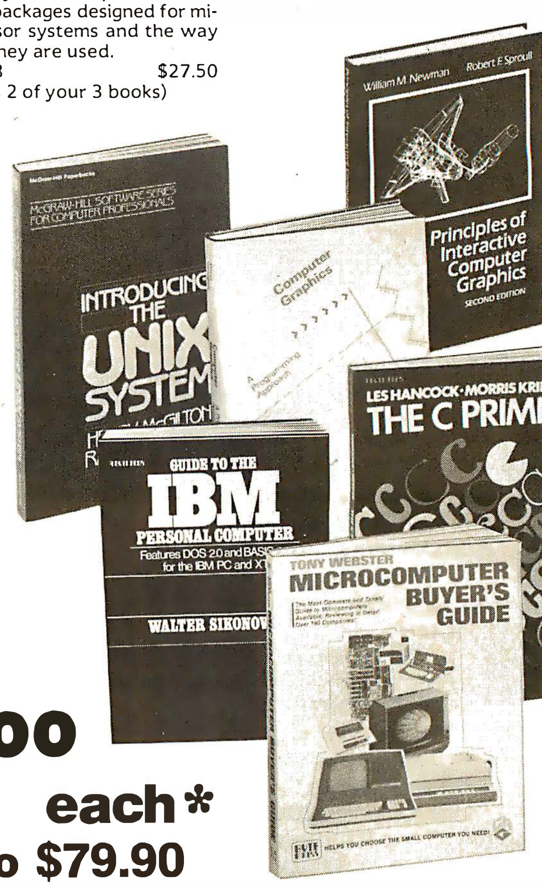
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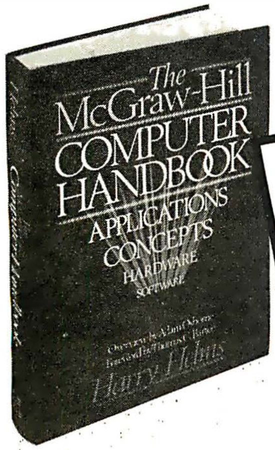
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BYTE's User to User

Conducted by Jerry Pournelle

From Logo to FORTH

Dear Jerry,

In BYTE's User to User, a reader implied that Logo is "baloney" (November, page 585). For several years I shared a similar opinion, but have recently reversed my thinking and see considerable value in Logo, particularly as a teaching tool. Two factors contributed to my about-face.

First, teachers understand Logo and are comfortable with it. As a result, they use it with confidence and encourage their students to use it. No other language has been received so well by teachers and has spanned such interest as Logo.

Second, Logo is the perfect language to introduce structured programming. When I teach FORTH to children or adults, I invariably begin with a version of Logo or Turtlegraphics. Most of my students can then make an easy transition to FORTH.

Logo has considerably reduced the level of technophobia among teachers, helping them to adjust to a new technology that is rapidly finding its way into the classroom. It is also a lot of fun, and school-age children find it challenging as well as enjoyable. Although there is no doubt there is more froth than substance to the Logo mystique, it is nonetheless a great instructional tool.

Michael N. Milone Jr.
Honesdale, PA

You are not alone in your admiration of Logo as a teaching language. Alas, DR Logo requires a color system, and we have only a monochrome for our IBM PC, while the Logo we have won't run with the Z-100, which is a color machine. Ah, well.

One day I'll get to play about with Logo and get Mrs. Pournelle interested in it. . . . **Jerry**

No Frills Nevada

Dear Jerry,

I have been following your column in BYTE for a few months now, and am grateful for the insight you've provided on those products that you've written about. I am curious, however, about a set of products advertised in BYTE from Ellis Computing, consisting of Nevada FORTRAN, EDIT, COBOL, and PILOT. Each product carries a $29.95 price tag and runs under CP/M (there are several disk formats available), so I am sure there must be a whole host of people in your audience who would benefit from this package if it is worthwhile enough. If you have already covered these software packages, forgive the intrusion, I only have a limited number of back issues of BYTE available.

John DaMassa
Davis, CA

I've had limited experience with the Nevada products, but what experience I have had is very good indeed. They're a bit "no frills" as you might expect from the price, but the stuff seems solid to me. I'm not overly enamored with the editor. . . . **Jerry**

Legal Clarification

Dear Jerry,

You and your readers are mistaken in most of your views regarding the legality of warranty disclaimers and license agreements sold in mass-marketed software. The following should provide a basic framework of the law:

Warranty Disclaimers

1. A manufacturer cannot disclaim an express promise. If the advertising, packaging, or operator's manual says a product will do "X," then it must.
2. A disclaimer first mentioned after the sale is void. The sales contract is "formed" at that instance. Any attempt to unilaterally modify a previously existing bilateral contract (between the seller and the purchaser) will fail for lack of consideration.
3. If the software is bought by a consumer and the seller provides a service contract (e.g., pay $20 in advance and you will be sent all updates as they occur), then the Magnuson-Moss Warranty Act, 15 U.S.C. §§2301–2312, provides that the warrantor may not disclaim the implied warranties of merchantability or fitness for a particular purpose.

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1. Software that is "*perpetually* licensed" is sold and not licensed.
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and its terms) probably has no legal effect. It has never been tested in court. However, such self-serving words when placed on an automobile check (e.g., parking-lot owner is not liable for damage done to your car) have been uniformly declared void.

There is a good discussion of the computer warranty issues in my book, *Computer Buyer's Protection Guide: How to Protect Your Rights in the Microcomputer Marketplace*, Prentice-Hall (ISBN 0-13-164195-6). There will be an in-depth analysis of software licensing in my next book, *The Law and Software*, also for Prentice-Hall.

L. J. Kutten
St. Louis, MO

Thanks for the briefing. However, why do you say I am mistaken? I've always believed those "licensing agreements" were unenforceable and unlikely to get any serious attention from a court, and I've said so, often.

If I were a software publisher, I'd rely on copyright law for protection, and not try to be a hog with "licenses." . . . **Jerry**

That's a Good Question

Dear Jerry,

You've made a fine contribution in promoting the phrase "Real Soon Now;" it rivals "The Check Is in the Mail" for implying implausibility. I recommend another useful phrase, which I'd appreciate your trying out on your friend Bill Godbout. It's a phrase I keep hearing from his Compupro dealers whenever I ask anything about my 68000/mapFORTH system.

The phrase is "That's a Good Question," and it is never accompanied by a useful answer. Examples: Why won't my system print using the Interfacer IV? Answer: TAGQ (in this case I was able to fix the bug myself). Why does the system refuse to boot if the Interfacer IV screens are precompiled? TAGQ. Can I add Compupro's hard disk under mapFORTH? TAGQ.

Compupro and its dealers seem to be concentrating on 8086 systems, which would be fine as long as they don't orphan the CPU-68K board. Since the dealers appear to know less than their customers about mapFORTH and the CPU-68K, we need someone knowledgeable at Compupro to whom we could talk directly. Perhaps you can convince Bill Godbout of the worthiness of this idea, and then publish the person's name and number in your column. At present, Compupro asks that we work through their dealers, which is useless. The CPU-68K is a good product, and it deserves Compupro's support.

Richard F. Olivo
Northampton, MA

I agree that Compupro hasn't provided enough software support for their 68000 board. Indeed, their software department isn't very large. After all, it's only been a year or so since Dr. Godbout's idea of user support was to read the spec sheet over the phone to those who called with questions about one of their boards!

They're getting better, and I'll pass your letter along; perhaps it will encourage more activity.

They're also putting their Systems Center dealers through intensive training. . . . **Jerry**

Correction and Update

Dear Jerry,

I recently read your review "The User Looks at Books" (December, page 519). I am pleased that your "current favorite beginner's text" is my book, *A First Course in Computer Programming Using Pascal* (McGraw-Hill, 1982). However, my first name was listed incorrectly. I have listed it below.

I consider learning to program as a process that requires quite some time and effort. It may be possible to cover a little about records and pointers in a first course; however, in-depth coverage of records and pointers is usually included in a second course. Consequently, my book does cover the use of linked lists to form stacks and queues. The success of *A First Course in Computer Programming Using Pascal* encourages me to consider writing a second-course text, in which advanced topics could be given more complete coverage.

Arthur M. Keller
Stanford, CA

I'm sorry I got your name wrong; our copy of the book has fallen victim to the Brotherhood of Book Borrowers, and alas, has gone away forever.

I don't disagree with your decision to limit the scope of an introductory book, but I did feel obliged to let the readers know. When you get the next book done, I'd like to see it. . . . **Jerry**



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Encryption and Security

Dear Jerry,

Here is the letter you requested outlining my thoughts on cracking Charlie Merrit's encryption program (see "Interstellar Drives, Osborne Accessories, DEDICATE/32, and Death Valley," July, page 323). The first point I would like to emphasize is that the purpose of this exercise, in my view, is not to see whether the trapdoor algorithm can be broken. I know enough about number theory and NP-completeness to know that the algorithm is fundamentally sound, and that nothing short of a major mathematical revolution is going to change that. What I am concerned about is the *implementation* of the algorithm. A flawed implementation can reduce the algorithm to total worthlessness. It is entirely possible that people could be buying encryption programs they believe to be "unbreakable," which in reality provide little or no security. The purpose of this exercise is to point out that it takes more than a good encryption algorithm to make data secure.

Merrit's program provides the service of generating the prime-number keys for the user. This is a valuable service, as it would be unreasonable to expect the average user to come up with 200-digit prime numbers! However, this service can also provide some security problems. Let's assume the existence of a similar program written by someone who decided to take a shortcut and built a table of possible keys into the program (acknowledging that Merrit's program does not do this). The keys are very large because the larger the keys, the harder it is to distinguish the private key from the public key. Let us further assume the program is a roaring success, and there are hundreds of thousands of users of it. Does the program really provide security? The answer is no. Now let there be a hacker who, as hackers are wont to do, decides to disassemble the object code to see what makes the program tick. Never mind how protected the object code may be; there always seems to be a way to get around the protection. Now, the hacker is obviously going to discover the table of primes. In all probability, this table will be quite large, so as to provide the maximum number of keys practical to give the user. However, even if there were 10,000 primes in this table, it would be a simple matter to have a computer try each one in turn to see if it is the private key that matches the known public key. A larger key length in this case would not offer much more security.

Even if the program in question did not use a table, but instead used a random-number generator, for example, there can still be problems. For example, if the random-number generator used a 16-bit seed, then the generator could produce only 65,536 distinct keys at most, no matter how long the keys were. Again, an exhaustive search for the private key becomes feasible. Even if the seed were significantly larger, there is still the problem of where the initial random seed comes from. Also, the random-number generator might be a very poor generator of random numbers. Just because the seed is a 64-bit number does not necessarily mean that the generator will produce all possible 2^{64} numbers. Especially if the programmer naively assumed that a super-duper complicated generator will produce "more random" numbers than a simpler, but mathematically guaranteed, producer of random numbers.

Even if it were not possible to get at the object code, it is still possible to crack the program if it can only produce a limited number of possible keys. Mathematically, there is no distinction between public and private keys; the two can be freely interchanged. Therefore, the key generator might produce the same key sometimes as a private key and sometimes as a public key. By running the key generating many times and saving the keys produced, it becomes possible that one of those keys might be the private key to go with the public key in question. Of course, with this approach, there is no way to know in advance whether it will work without trying it.

From what I have been told, I doubt that Charlie Merrit's program can be broken. However one can never be sure, and there's only one way to find out.

Jeff Cohen
Sunnyvale, CA

I've talked to Charlie Merrit, and he just chuckles; but he's willing to furnish you with a copy of his encryption program to work on. He says he uses the refresh counter on the Z-80 chip for his random-number source, and that's affected by barometric pressure and the phases of the Moon.

It really looks as if we've got unbreakable codes we can implement on micros. The implications are a bit staggering. "But Your Honor, I only have the public key. I can't decode those records . . ." . . . **Jerry**



Photo: Peter B. Kaplan

If you still believe in me, save me.

For nearly a hundred years, the Statue of Liberty has been America's most powerful symbol of freedom and hope. Today the corrosive action of almost a century of weather and salt air has eaten away at the iron framework; etched holes in the copper exterior.

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Inspiring plans have been developed to restore the Statue and to create on Ellis Island a permanent museum celebrating the ethnic diversity of this country of immigrants. But unless restoration is begun now, these two landmarks in our nation's heritage could be closed at the very time America is celebrating their hundredth anniversaries. The 230 million dollars needed to carry out the work is needed now.

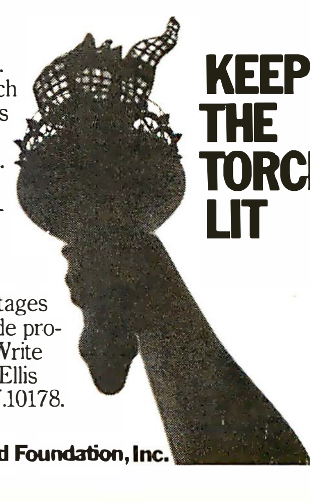
All of the money must come from private donations; the federal government is not raising the funds. This is consistent with the Statue's origins. The French people paid for its creation themselves. And America's businesses spearheaded the public contributions that were needed for its construction and for the pedestal.

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Reflections on PL/I

Dear Jerry,

As a long-time science-fiction buff I have always enjoyed your writing, in *Analog* as well as BYTE. But I should introduce myself . . .

My name is Kelly Cook. I was employed for 19 years at Kitt Peak National Observatory, first as an observer, later as an optician. As such, I specialize in the testing of large mirrors, which is how I got involved with computers and programming. In 1981, I left Kitt Peak to attempt a career change to programming. On the nonprofessional side, my main passion is designing war games.

What prompted this letter was your mention in BYTE about gathering times on different systems for your benchmark ("New Computers, Books, Languages, and Other Tidbits," October, page 107). So here is PL/I-86 on an IBM PC, wreaked keyboard and all (see listing 1). This was made possible by my client, Arizona Technologies, who makes large mirrors for telescopes. The client asked me to write a program for interferometric testing on the PC. Of course, such programs have traditionally been done in FORTRAN on mainframes. Wanting to stick with FORTRAN, I started out with IBM's UCSD FORTRAN77. But a subroutine to put a very crude map of a mirror surface on the screen took 10 minutes to complete! With panic, I then turned to PL/I-86. Now the same routine takes only 14 seconds!

Your benchmark ran so fast that I added a 10-iteration loop to give my simple watch a better handle on it. The result of 92 seconds can then be divided to give a corrected time of 9.2 seconds (20 by 20 arrays). CP/M-86's Stat gave the object file size as 2K, but that is the smallest size that Stat can report so it's probably not very accurate. Linkage is another story. To make an object file into an executable COM file, it first has to be linked with PL/I's library of Built-In Functions. This means a great deal of disk grinding and a final file that Stat reports as 20K!

I had heard the tales about PL/I being a bear to learn. My experience is with FORTRAN and BASIC, plus a little dabbling in FORTH, C, and Pascal. PL/I may not be as simple as BASIC, but it's certainly easier to understand than C or FORTH. It should be a snap for anybody who already knows Pascal. Just read the listing of your benchmark and see for yourself! The provisions for pointers and recursion can be tricky, but that is intrinsic in those concepts. Those things are just as tricky in Ada or C. And they are options, after all, so you can just ignore them if you want.

The bottom line is that PL/I-86 can be a bona fide lifesaver for anybody doing large-scale number crunching on a micro.

Kelly Cook
Tucson, AZ

My late mad friend, Dan MacLean, became a PL/I enthusiast in his last year. Had he lived, I make no doubt that he would have converted me; Dan had his ways.

However, without his stimulus I became a backslider. Most of my previous programs have been done in CB-80. Most of my future ones will be done in Modula-2. We have PL/I, but so far I've done almost nothing with it.

But Dan Alderson (inventor of the Alderson Drive for those who've read The Mote In God's Eye*) is a PL/I enthusiast, and as soon as he's properly set up with a machine, I'll have a PL/I consultant. . . .* **Jerry**



Circle 139 on inquiry card.

BYTE's User to User

Listing 1: *The program below performs a series of matrix operations to provide a benchmark. The original benchmark was published by Jerry Pournelle in "A BASIC and Pascal Benchmark, Elegance, Apologies, and FORTH" (October 1982, page 254). It's run ten times to allow more accurate measurement.*

```
MATRIX:
procedure options(main);

%replace
        maxsize by 45,
        m       by 20,
        n       by 20;

declare
        i, j, main_loop,
        (A, B)(m,n)  float,
        C(m,n)       float static initial(0.0),
        Summ         float static initial(0.0),
        BELL         char,
        GUP          var char(80);

put skip list('input any darned number to start it.  ');
get list(GUP);

do main_loop = 1 to 10;

  call FILLA;
  put skip(3) list(' A filled.');

  call FILLB;
  put skip list(' B filled.');

  /*  FILLC call replaced by "initial" option during declaration   */

  call MATMULT;
  put skip list('Multiplied.');

  call SUMMIT;
  put skip(2) list('Summ is ', Summ);


 FILLA: procedure;

        do i = 1 to m;
          do j = 1 to n;
            A(i,j) = i + j;
            end;
          end;

        end FILLA;

 FILLB: procedure;

        do i = 1 to n;
          do j = 1 to m;
            B(i,j) = fixed((i + j) / j);
            end;
          end;

        end FILLB;

 MATMULT: procedure;
        declare k;

        do i = 1 to m;
          do j = 1 to n;
            do k = 1 to m;
              C(i,j) = C(i,j) + A(i,k) * B(k,j);
              end;
            end;
          end;

        end MATMULT;

 SUMMIT:. procedure;

        do i = 1 to m;
          do j = 1 to m;
            Summ = Summ + C(i,j);
            end;
          end;

        end SUMMIT;

 end;                        /*  end main_loop   */

BELL = ascii(7);
put list(BELL);

end MATRIX;
```

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A Mariner Queries

Dear Jerry,

I just recently began reading BYTE and liked it so much that I rounded up some old issues. In your discussion of the 8087 ("New Computers, Boards, Languages, and Other Tidbits," October, page 107), you mentioned a lack of supporting software. Probably you know this by now, but Microsoft's implementations of FORTRAN and Pascal both fully support the 8087.

The real reason I'm writing is to find out if you have tested the piggyback 8087 board in your Z-100. If not, could you be persuaded to do so? I will be buying an H-100 in a few weeks. It will eventually be installed in the ocean-cruising sailboat I'm building, where it will serve as a navigation tool. Since number crunching is an inherent feature of navigation, I am extremely interested in having the 8087. It seems to me that a board that works in the Compupro ought to work in the Z-100, but it would sure be nice to know for certain. Can you help?

The last issue of the Heath Users' Group magazine, *REMark*, contained a couple of pieces of information that might interest you. Zenith is working on an interlaced scan routine to double the vertical resolution of the Z-100 display. At 640 by 450 pixels, it should be fantastic. Also, Zenith won a DOD contract competition and the Z-100 will be *the* desktop computer in all four military services. Will we be seeing Ada before long?

Robert D. Williams
Hampton, VA

Regarding 8087 boards for the Z-100, watch my column. The Hudson board for the Compupro will not *work with the Z-100; but the good news is that yesterday Jim Hudson called to say he'd finished the prototype Z-100 board. I haven't seen that board working yet, but I do have his add-on for my Compupro; and I know Jim well enough to have some confidence that his final product will be reliable. He's a perfectionist, and does his own work.*

I've asked around, and my colleagues tend to agree that the H-100 is a good choice for your navigation computer, provided that you've given sufficient thought to waterproofing. I presume you've enough salt-water experience to appreciate just how serious corrosion problems can be. I'd particularly worry about the mechanical parts, such as switches, keyboards, fans, and floppy disks.

The Zenith is a good, rugged machine. The only one I can think of that's even more so is the Compupro, and that's heavy enough to serve as a keel.

Good luck on your cruise, and keep me posted. Long ago I did a bit of blue-water midget ocean racing, and I've read Slocum and Hiscock and the other classics. I still delude myself that one day I'll take a long sailing cruise. . . . **Jerry**

A General Comment from Jerry

In the interests of sanity, we threw away all the mail dated prior to September 1, 1983. This wasn't easy to do, because there were some excellent letters that deserved reply; but it became obvious we just weren't going to keep up, and the sight of all that unanswered mail was depressing.

If you wrote earlier than that and still want an answer, please write again. This includes discussions of software for review. We have a somewhat better system now, and we're caught up for the moment.■

Jerry Pournelle is a former aerospace engineer and current science-fiction writer who loves to play with computers.

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed envelope to Jerry Pournelle, c/o BYTE Publications, POB 372, Hancock, NH 03449. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply.

BYTE's Bits

Call for Papers

A call for papers has been issued by Computer Faire, sponsors of the annual West Coast Computer Faire and the PC Faire. The call is for papers to be delivered at next year's conference programs. The West Coast Computer Faire will be held in San Francisco on March 23-25, 1984. The dates for the PC Faire, also to be held in San Francisco, will be October 26-28, 1984.

Interested parties are invited to request a speaker's kit from Computer Faire Inc., 570 Price Ave., Redwood City, CA 94063, (415) 364-4294.■

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WANG

The Office Automation Computer People.

BY 5

Ask BYTE

Conducted by Steve Ciarcia

S-100 Versatility

Dear Steve,

I would like to learn assembly-language programming for the Motorola MC68000. There seem to be add-ons for the Apple that let you get an inexpensive system for a reasonable price, but none is available for a CP/M system. I have an S-100 Delta CP/M system with 64K bytes of RAM. Can I buy an inexpensive (much less than $2000) S-100 board that would let me do it? Whatever system I bought would have to include a 68000 software-development system.

Would it be possible to design a modular system so that a person with a complete, one-processor system could add one or more additional processors, some RAM, or whatever was needed? What I'm talking about is a generalized hardware converter analogous to software converters for disk formats. The S-100 bus was supposed to be something like that, but I have had my Delta for two years and have yet to add my first board to it because I've never seen anything I wanted badly enough to pay the "Rolls-Royce" prices that S-100 bus designers seem to have to charge.

With an external converter, you could add whatever you wanted, even a Commodore 64 or VIC-20, to your big CP/M system and get pretty good color and all the things a large system does. With something like that, people might be able to combine all the little goodies you've designed.

Dean Dwyer
Torrance, CA

Your letter addresses quite a few good questions. Let me answer them somewhat out of the order you posed them.

First of all, you have already taken the direction of a generalized system when you selected the S-100 bus. Any system designed around a popular bus will offer quite a bit of user flexibility. The S-100 bus is also very much alive and well since the introduction of the IEEE-696 proposed standard. Estimates of the number of S-100 bus systems in operation range around 500,000.

I do agree with your statement about the "Rolls-Royce" prices of some of the commercial boards offered for the S-100 bus. The way around these prices is to buy bare boards or to construct your own boards. A good reference manual for interfacing your own boards to the S-100 bus was written by Sol Libes and Mark Garetz, Interfacing to S-100/IEEE 696 Microcomputers, *published by Osborne/McGraw-Hill. For example, you should be able to interface the speech generator with the information in this reference.*

Another good source for S-100 and CP/M information is the monthly publication called Microsystems. *Some advertisers in* Microsystems *have been addressing the question you have on running 68000 software with your 8-bit system. For example, HSC Inc. is advertising a C016 resource processor to run CP/M-86, CP/M-68000, MS-DOS, or Unix on a Z80 system (see* Microsystems, *September 1983, page 23). Avocet Systems Inc. is advertising several cross-assemblers that run on any computer with CP/M. Its ad claims to have a 68000 version coming soon (see BYTE, November 1983, page 435)....* **Steve**

Income Tax Software

Dear Steve,

I have a Commodore 64 with a floppy disk, and I'm running Microsoft BASIC and CP/M-80. Could you tell me what software is available for state and federal corporate and personal income taxes? Thanks.

Chester Fuchs
Yonkers, NY

Several income tax programs are available for the Commodore 64. Two that recently have been advertised are: The Complete Personal Accountant (Programmer's Institute, POB 3470, Dept. C, Chapel Hill, NC 27514, (800) 334-7638), which is a combination of programs for accounting, budget, mailing lists, spreadsheets, and income taxes; and Tax Command (Practical Programs Inc., POB 93014-S, Milwaukee, WI 53203, (414) 278-0829), which features built-in tax tables and most of the commonly used schedules.

From the advertisements, it appears that both programs are designed for personal income tax preparation. I am not aware of a program for corporate or state income tax for the Commodore 64.... **Steve**

Portable Terminal

Dear Steve,

I'm looking for a small portable terminal. My current line of thinking is to adapt a Radio Shack Pocket Computer, but I have had no luck obtaining technical information. Can you provide a source for technical information on the construction and internal operation of the PCs? Thank you for your help.

Tim McDonough
Springfield, IL

The IXO Telecomputing System sounds like the ideal solution to your problem. It features a keyboard with a full ASCII character set, has a built-in modem with autodialer, can emulate other terminals, has an uninterruptible power supply (battery), and can fit in your pocket. In addition, it has optional RS-232C and video interfaces and a 20-column printer. Best of all, its price starts at about $500. A review of this unit was presented in the April 1982 BYTE (page 6) and the May 1982 Popular Computing *(page 16). For further information, contact IXO Industries Inc., 6041 Bristol Parkway, Culver City, CA 90230, (213) 417-8080.*

If you have the urge to build your own, see my January and February 1984 article ("Build the Circuit Cellar Term-Mite ST Smart Terminal) on a low-cost, high-performance terminal.... **Steve**

Give Me a Break Key

Dear Steve,

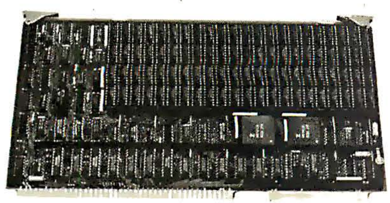
I have written a communications program for my Commodore VIC-20 that lets me do much work from home. I am communicating with a Honeywell 6000 Level 66 mainframe. The problem is that the VIC-20 doesn't have a Break key, so I cannot exit any loops. I have tried sending many different ASCII values but have had no success. The Honeywell documentation does not mention how its terminals implement the Break function. If you know how to solve this problem, I would greatly appreciate it.

Michael J. McCarthy
Pittsburgh, PA

The Break key is used to indicate a need for immediate attention. It is a unique signal and is not in the standard ASCII code. Pressing the key causes the data line to go high for approximately 300 milliseconds, which is interpreted by the computer as a Break signal. This condition always occurs when operating in a full-duplex mode, but it can oc-

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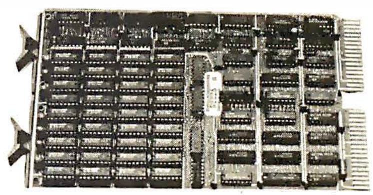
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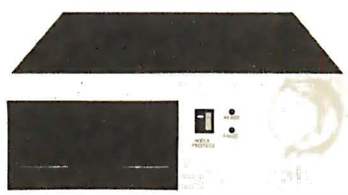
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cur during half-duplex operation only when the terminal is transmitting. When the computer is transmitting, the Break key is unrecognized. A simple way to achieve this 300-ms pulse is through the use of a one-shot circuit activated by the Break key. . . . **Steve**

Laboratory Automation

Dear Steve,

I am a radiological physicist and part of my work consists of the calibration of X-ray generators used in the treatment of cancer. Much of the work consists of the manual positioning of an ionization probe or diode within the radiation beam and then sampling the probe with an electrometer. The electrometer has a convenient output for use with analog plotters with inputs ranging from 0 to 10 volts (V) DC. This voltage is proportional to the radiation intensity.

The problem is the time, energy, and wear and tear on the equipment, and myself, when taking these measurements. Entering the room, walking a distance of 50 feet or so, opening and closing a one-ton door, positioning the probe, and starting and stopping the machine is a process that takes nearly four minutes per reading. Acquiring enough points to generate a beam profile can take several hours.

I have a TRS-80 Model III and a Starbuck Data Model 8882. The latter has an 8-channel 8-bit analog-to-digital (A/D) converter, eight on/off switch inputs, and eight on/off switch outputs. I am very happy with the 8882, and with the addition of a few simple circuits, which I hope you can provide, I will be able to perform my job much more effectively.

First, I would like to be able

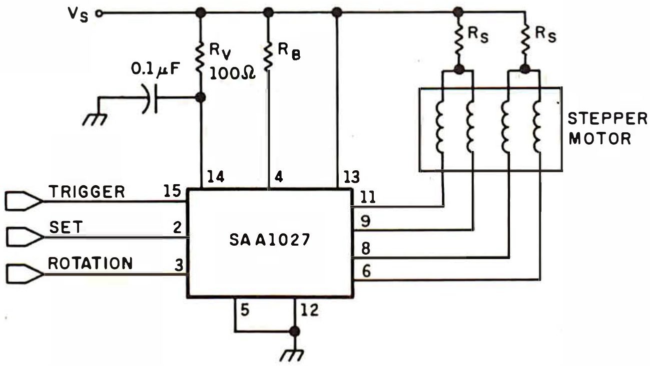


Figure 1: *Stepper-motor controller.*

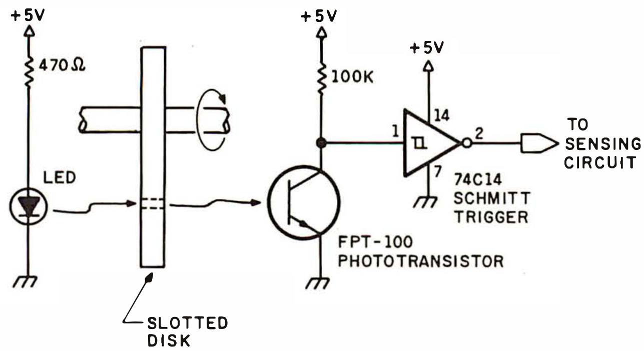


Figure 2: *Position-limit sensor.*

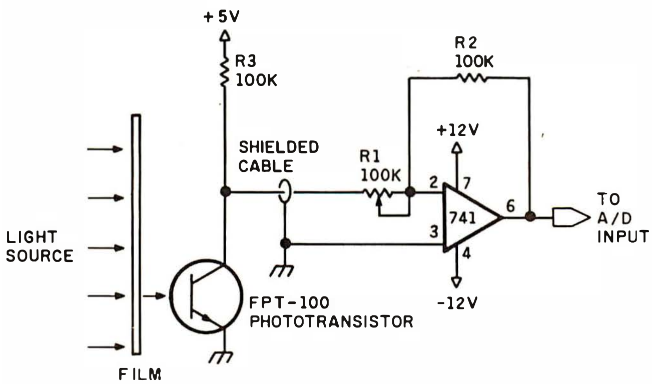


Figure 3: *DC amplifier/scaler.*

to control a three- or four-phase stepper motor with the opto output switches of the 8882. The stepper must have about 30 ounce-inches of torque to function effectively. I intend to keep track of the position of the probe by the number of pulses in either direction. I need a simple stepper-motor controller capable of direction and stepping logic from two of the eight output switches of the 8882.

Second, I need a limit switch capable of accurately sensing a position to a millimeter or less, possibly some sort of optical device. This circuit would be used to reference the stepper motor.

Third, I need a circuit that would convert film optical density into a voltage proportional to film density. I will use this device to convert a film exposed to the radiation beam into a dose profile. The stepper will be used to automatically move the film over the density reader.

Last, I need a DC amplifier that will convert a voltage from the electrometer, or film-density reader, into a voltage in the range of 0 to 5 V for the Starbuck 8882 A/D. Because the electrometer may range from 0 to 10 V and the film-density reader also may vary out of the 0- to 5-V range, I need the capability of offset as well as amplification greater than and less than one to get the voltage between 0 and 5 V for the 8882. This will enable me to get full resolution out of the 8882.

I need circuits that are simple to build and understand because I have a very limited knowledge of electronics.

Your help could make a substantial contribution to the effectiveness of my job and the treatment of our patients.

Dwight T. Still
Lawrenceville, GA

Automating your TRS-80 to acquire beam profiles can be accomplished with some simple circuits and a little research into stepper motors.

Several manufacturers are now producing stepper motors that will match your needs. In particular, North American Philips Controls Corporation offers both the stepper motors and an integrated-circuit pulse-to-step drive controller in 16-pin DIP (dual-inline package). It also offers a Stepper Motor Handbook *with all the information needed to design a stepper-motor device. You can obtain this handbook from North American Philips Controls Corp., Cheshire, CT 06410, (203) 272-0301.*

Figure 1 was gleaned from the Stepper Motor Handbook *and shows how simple the circuitry is with the SAA1027 controller. The direction of rotation is controlled by applying a low or high level to pin 3. The motor will step when a low-to-high transition occurs on pin 15. The*

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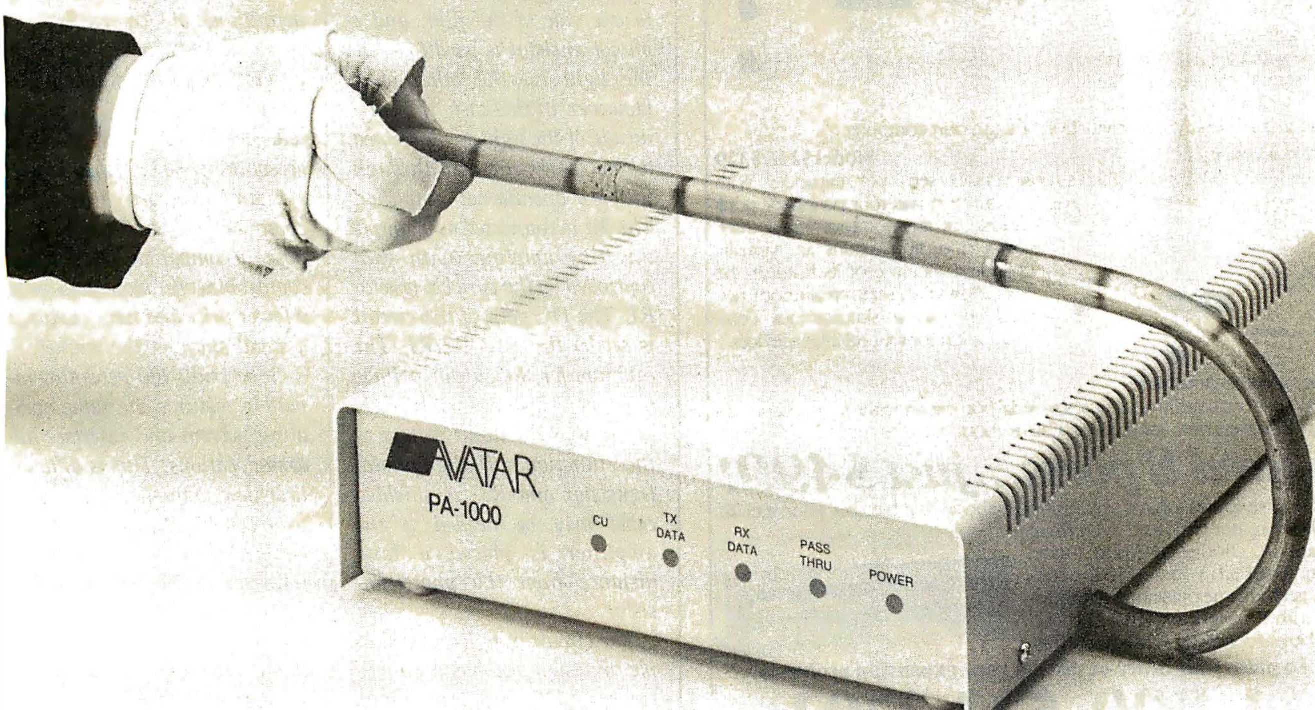
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values of R_s and R_b depend on the stepper motor chosen and the value of V_s. These values are tabulated in the handbook for various stepper motors.

Figure 2 shows a simple method of obtaining a reference position for the stepper motor. The method is analogous to the methods used in disk drives. An opaque disk with a small hole or slot can be mounted on the shaft of the stepper motor. A light source, such as an LED, can be mounted on one side of the disk and a phototransistor on the other side. When the light passes through the slot, the phototransistor will conduct and the voltage at pin 1 of the 74C14 Schmitt trigger will go to approximately 0 V. The Schmitt trigger will now convert this voltage change into a sharp 0-to-5-V transition at its output. This transition can now be monitored by a voltmeter or fed into one of the on/off switch inputs on the Starbuck 8882.

Figure 3 shows one simple method of converting a film density into an analog voltage. Again, a light source is applied to one side of the film, and a phototransistor is used to sense the light on the other side. However, in this case, the magnitude of the light is monitored by your A/D circuitry through the 741 operational amplifier. The 741 is connected as a simple inverting amplifier with gain controlled by the variable resistor R1. The DC gain of the circuit is set by the ratio R2/R1. The equation for the output voltage (V_o) is $V_o = V_i \times R2/R1$, where V_i is the input voltage at the junction of the phototransistor and R3. A shielded cable may be needed if the amplifier is placed a long distance from the phototransistor.

The circuit in figure 3 is simple in design and has no provisions for DC drift that can be caused by several factors, including ambient temperature changes. If small drift errors are a problem, you can find any number of texts on operational-amplifier design at most public or company libraries and at most bookstores. . . . **Steve**

Compatibility Revisited

Dear Steve,

As a businessperson who is a small computer user, I share the sentiments and frustrations of the first-, second-, and even third-time purchasers of small computers. In their ads, many companies claim "Apple compatible," "will run most software for. . . ," "IBM compatible," or "runs CP/M software."

What are the main aspects of a computer and software that would make them truly "IBM" or "Apple" compatible? An article on this would be of great service for those of us who don't hold advanced degrees in computer science and engineering.

Jeff Van Buren
Morehead City, NC

There are almost as many definitions of "compatible" as there are "compatible computers." A good definition of a compatible computer is one that will run the same software and accept the same hardware expansion and accessory cards as the computer with which it is supposedly compatible. Some of the compatibles offer more features at a lower price and have captured a small share of the market.

To be truly 100 percent compatible requires the same operating system and interface address locations. This is difficult to achieve without violating software copyrights, so most "compatible" computers lack certain features. CP/M allows the closest compatibility because the operating system is the same and the BIOS (basic input/output system) accounts for the hardware variations. Unfortunately, disk sizes and formats have not achieved this level of compatibility.

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subject for an article, but it would have to concentrate on a particular computer. Trying to cover the field would require an encyclopedia. . . . **Steve**

ZX81 Floppies and Interfaces

Dear Steve,

I have a Sinclair ZX81 and would like to use a floppy-disk drive with it. I know that I will also need an interface. Are there a drive and an interface that you know about that could be used? Thank you.

Denis Boulais
Iberville, Quebec, Canada

A floppy-disk interface is available for the Sinclair ZX81/Timex 1000 that will allow the use of the popular Shugart SA200 disk drives. Software commands include saving and loading BASIC programs as well as data, initialization of a disk, CREATE, READ, WRITE, KILL, STAT, DIR(ectory), and NEWD(isk). All of these functions can be called from programs or from the immediate mode.

The FDC-100 interface is available for $199. A single-drive package that includes interface, drive, and power supply (FDC-101) is $499; a two-drive package (FDC-102) costs $799. Contact Compusa, 1101 Bristol Rd., Mountainside, NJ 07092, (201) 654-7220. . . . **Steve**

Prototype Boards

Dear Steve,

I have been looking for a prototype board like the one pictured on the front of your book, *Build Your Own Z80 Computer*. The only boards I can find have extra pads for regulators, etc., which make them unsuitable for your application.

Would you please let me know the manufacturer and model number of the card you used?

Robert Kanen
Long Valley, NJ

Vector Electronics has a complete line of prototype boards for many computer buses. The board shown on the cover of my book uses a 72-pin connector and was designed for the Digital Group system. I am not sure if this particular board is still available. Even if it is, obtaining 72-pin sockets will be very difficult.

I recommend one of the S-100 prototype cards that are made by Vector. The company has almost a dozen different combinations, from a blank, unetched printed-circuit board to one with power buses and pads. You will need a catalog to choose. Remember, too, that traces can be cut and rerouted to accommodate your layout.

Should you decide to expand your system, motherboards and cabinets will be readily available with the S-100 pinout and geometry.

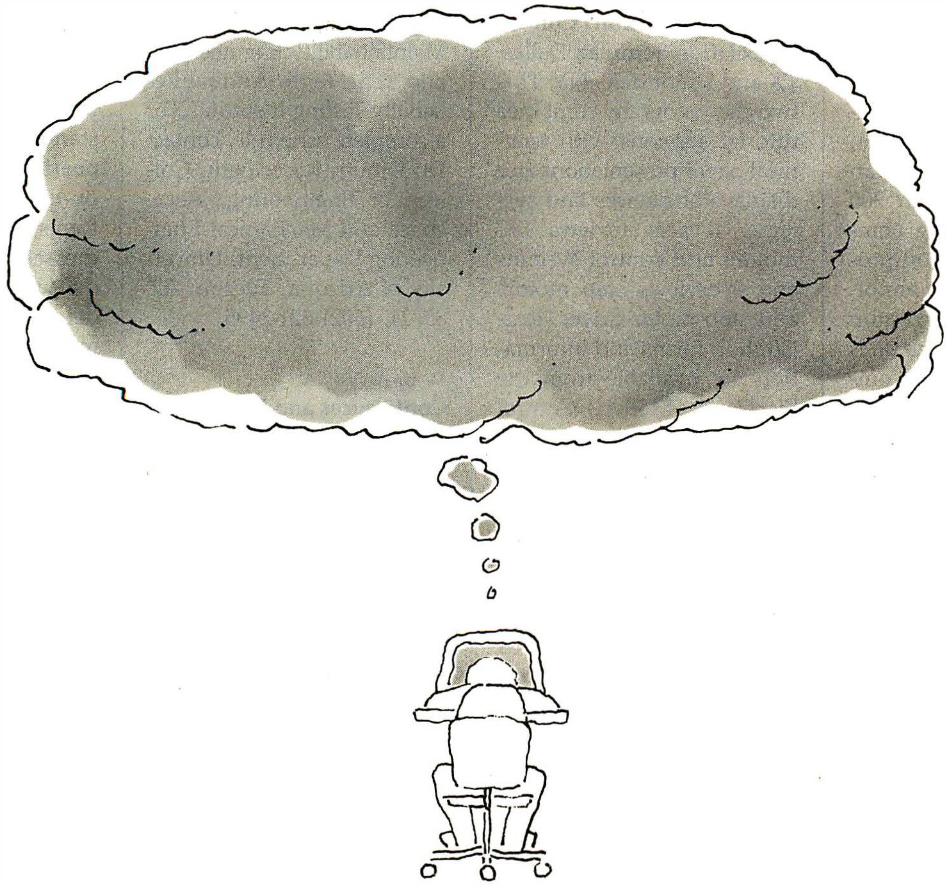
A catalog can be obtained from your local electronics dealer or from Vector Electronics Company, 12460 Gladstone Ave., Sylmar, CA 91342, (818) 365-9661. . . . **Steve**■

In "Ask BYTE," Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to:
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Continuing Engineering Education Courses, Washington, DC, Orlando, FL, and San Diego, CA. More than 300 courses for practicing computer and information-processing professionals are offered by George Washington University. A few of the titles include "Local Area Computer Networks," "An Applications-oriented Approach to Artificial Intelligence," and "Minicomputers, Microcomputers/Processors for Nonelectrical Engineers." Fees range from $625 to $875. Contact Continuing Engineering Education, School of Engineering and Applied Science, George Washington University, Washington, DC 20052, (800) 424-9773; in the District of Columbia, (202) 676-8522.

March–April
Courses from Integrated Computer Systems, various sites throughout the U.S. "Implementing Local Area Networks," "Designing Dedicated/Embedded Computer Systems," and "Computer Network Design and Protocols" are a few of the courses to be presented. For course information, contact Ruth Dordick, Integrated Computer Systems, 6305 Arizona Place, POB 45405, Los Angeles, CA 90045, (213) 417-8888.

March–April
Courses in C Language and Unix, various sites throughout the U.S. Three five-day courses are offered: "C Programming Workshop," "Advanced C Topics Seminar," and "Unix Workshop." For complete details, contact Joan Hall, Plum Hall Inc., 1 Spruce Ave., Cardiff, NJ 08232, (609) 927-3770.

March–April
Electronic Motion Control Association Seminar, Dallas, TX and Uniondale, NY. This two-day program combines tutorial sessions with technical paper presentations and displays of devices and systems. It also reviews DC motors and control systems and overviews step motors and step-motor drives. Registration forms and information are available from the Electronic Motion Control Association, Suite 1200, 230 North Michigan Ave., Chicago, IL 60601, (312) 372-9800.

March–June
Productivity '84, various sites throughout the U.S. This series of two-day programs serves as a showcase for Hewlett-Packard products. Seminars are available, and more than 25 products are to be demonstrated, including the HP 150 personal computer and laser printers. Admission is free to the public. For more information, contact Hewlett-Packard, Public Relations Department, 3000 Hanover St., Palo Alto, CA 94304, (800) 554-4466.

March–June
Seminars from Datapro Research Corporation, various sites throughout the U.S. Subject areas include data communications, microcomputers, and information systems. In-house presentations of technical programs can be arranged. For a 40-page catalog of seminars, contact Datapro Research Corp., 1805 Underwood Blvd., Delran, NJ 08075, (800) 257-9406; in New Jersey, (609) 764-0100.

March–July
Reliability and Maintainability Engineering Institutes and Short Courses, various sites throughout the U.S. A few of the programs to be offered are "Reliability Engineering, Testing, and Maintainability Engineering" and "The Tenth Annual Reliability Testing Institute." For a complete schedule, contact Dr. Dimitri Kececioglu, College of Engineering, Aerospace and Mechanical Engineering Department, University of Arizona, Tucson, AZ 85721, (602) 621-2495.

March–August
Conferences and Expositions from the Society of Manufacturing Engineers, various sites throughout the U.S. and around the world. More than 25 conferences and expositions are scheduled. For a calendar, contact the Public Relations Department, Society of Manufacturing Engineers, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-0777.

March–October
Tutorial Short Courses from Hellman Associates, various sites throughout the U.S. Among the courses offered are "VLSI Design," "Digital Control," and "Error Correction." Fees are generally $895. For a descriptive brochure, contact Hellman Associates Inc., Suite 300, 299 California Ave., Palo Alto, CA 94306, (415) 328-4091.

March 12–14
Auditing and Controlling Microcomputers, Houston, TX. This seminar reviews the technology behind microcomputers and shows how they can be used by an auditor for practice management or as a tool in an audit engagement. For a course outline, contact Miriam Hoyt, MIS Training Institute Inc., 4 Brewster Rd., Framingham, MA 01701, (617) 879-7999.

March 12–14
Softside of Software, Hilton Harvest House, Boulder, CO. Examining the many facets of writing user-friendly software and documentation, this seminar focuses on documentation techniques, standards, software engineering tools, and designing on-line help. User and customer training are also addressed. The cost for all three days is $595. For registration details, contact Cross Information Co., Suite B, 934 Pearl Mall, Boulder, CO 80302-5181, (303) 499-8888.

March 12–15
Interface '84, Convention Center, Las Vegas, NV. For details on this twelfth annual data communications/information-processing conference and exposition, contact the Interface Group Inc., 300 First Ave., Needham, MA 02194, (800) 325-3330; in Massachusetts, (617) 449-6600.

March 12–16
Auditing in the Contemporary Computer Environment, New York, NY. Participants will learn a comprehensive audit approach for computer-based systems. Topics include how to evaluate controls, how to prepare an audit report, and how to design a program of tests using questionnaires, checklists, software tools, and flowcharts. Contact the EDP Auditors Foundation, 373 South Schmale Rd., Carol Stream, IL 60187, (312) 682-1200.

March 13
NorWesCon-84, Red Lion Inn Convention Center, Bellevue, WA. The theme of this ninth annual Pacific Northwest industrial electronics trade show is "Discover Solutions in Technology." Almost 50 manufacturers will present exhibits, demonstrations, and seminars of original-equipment manufacturing and end-user products for

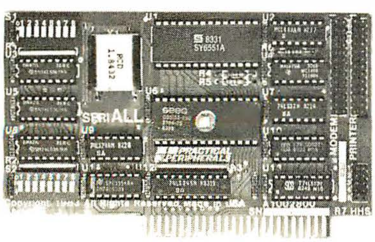
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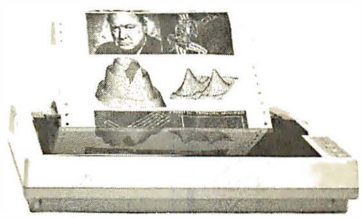


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the industrial electronics marketplace. Admission is free for all members of the industry. For information, call the sponsor, Almac Electronics Corp., 14360 Southeast Eastgate Way, Bellevue, WA 98007, (206) 643-9992.

March 13–15

CIMCOM, Convention Center, Washington, DC. The Computer-integrated Manufacturing and Communications (CIMCOM) conference and exposition is sponsored by the Computer and Automated Systems Association of the Society of Manufacturing Engineers (CASA/SME). It will focus on software development and applications, beginning with manufacturing planning and continuing through the manufacturing-control processes. For information, contact CASA/SME, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-1500, ext. 521.

March 13–15

Micro/SET 84: Microcomputer Expo for Science, Engineering, and Technology, Engineering Society of Detroit, MI. Papers emphasizing microcomputer applications in research, design, engineering, and manufacturing will be presented. Complementing the conference program will be displays of scientific, engineering, and technical microcomputer hardware and software. For more information, write to the Conference Manager, Engineering Society of Detroit, 100 Farnsworth, Detroit, MI 48202.

March 13–15

Online Business Strategy Conferences and Exposition, Barbican Centre, London, England. Three concurrent conferences will be held: Mobile Communications, Telecoms Today, and Satellite Communications. Multiple-conference session registration is optional. Organized by Online Conferences Ltd., Registrations Dept., Pinner Green House, Ash Hill Dr., Pinner HA5 2AE, Middlesex, UK; tel: 01-868 4466; *Telex:* 923498 ONLINE G.

March 13–15

Optical Storage of Documents and Images, Biltmore Hotel, Los Angeles, CA. Topics to be covered are read-write and read-only storage of analog and digital information including office documents, engineering drawings, and parts catalogs. The fee is $695 for the first person from an organization and $595 for each additional attendee. For more information, contact Technology Opportunity Conference, POB 14817, San Francisco, CA 94114-0817, (415) 626-1133.

March 13–16

Inside the IBM PC, Sheraton-Hartford Hotel, Hartford, CT. This intensive seminar explores IBM PC-DOS, hardware, communications, networking, and graphics. It's designed for advanced IBM PC or XT users, programmers, engineers, and designers. The fees are $345 per participant for a single day or $295 per participant per day for two or three days. In-house presentations can be arranged. Contact the Center for Continuing Education, Northeastern University, 360 Huntington Ave., Boston, MA 02115. For information on in-house presentations, call (617) 329-8000.

March 14–16

The Seventeenth Annual Simulation Symposium, Bay Harbor Inn, Tampa, FL. Papers dealing with applications of simulation, simulation languages, and methodologies will be presented. Contact Alexander Kran, IBM Corp., B/300-40E, Hopewell Junction, NY 12533, (914) 894-7142.

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March 14-18

Managing the Audit Computer-based Bank Systems, Washington, DC. This course provides a comprehensive audit approach for evaluating and testing controls in computer-based bank systems. Information is available from Darlene Floading, Bank Administration Institute, 60 Gould Center, Rolling Meadows, IL 60008, (312) 228-6200.

March 15-16

Technology Outlook, Wisconsin Center, Madison, WI. This seminar, conducted by the University of Wisconsin—Extension Engineering and Applied Science program, is designed for industrial executives seeking an understanding of telecommunications, automation, computer advances, and genetics. The fee is $475. For information, contact the University of Wisconsin—Extension, Department of Engineering and Applied Science, 432 North Lake St., Madison, WI 53706, (608) 262-3748.

March 17

The Sixth Annual Delaware Computer Faire, Delaware State College, Dover. Workshops, demonstrations, and sessions on the uses of computers in the classroom will be held. This program is tailored for kindergarten through senior high school teachers, administrators, and parents. Hardware and software will be exhibited. Contact Dr. William J. Geppert, Department of Public Instruction, Townsend Building, POB 1402, Dover, DE 19903, (302) 736-4885.

March 18-22

Saudicomputer '84—The Business Computer Show, al-Dhiafa Exhibition Centre, Riyadh, Saudi Arabia. For information, contact Philip Jenkinson, Saudicomputer '84, Overseas Exhibition Services Ltd., 11 Manchester Square, London W1M 5AB, UK; tel: 01-486 1951; Telex: 24591 Montex G.

March 19-21

The First Annual Computer Furniture and Home Office Show, Serra Grand Ballroom, Convention Center, Monterey, CA. Approximately 100 exhibits are planned. Seminars designed to introduce manufacturers and retailers to marketing and merchandising techniques will be conducted. For further details, contact National Fairs Inc., 1902 Van Ness Ave., San Francisco, CA 94109, (415) 474-2300.

March 19-21

Material Characterization Techniques for Integrated-Circuit Processing, San Mateo, CA. This three-day course is designed to acquaint participants with current techniques for integrated-circuit development, process monitoring, and failure analysis. The course fee is $450 for lectures only or $695 for the third-day lab session. For information, contact Continuing Education in Engineering, University of California Extension, 2223 Fulton St., Berkeley, CA 94720, (415) 642-4151.

March 19-22

Automated Manufacturing Conference and Exhibition (AM84), Textile Hall, Greenville, SC. Representatives from more than 200 firms will present the latest automated manufacturing technologies at this combination exhibition and seminar. Conference details can be obtained from the AM84 Registration Control Center, POB 5616, Station B, Greenville, SC 29606, (803) 242-3170, ext. 260. Exhibition details are available from AM84, POB 5823, Greenville, SC 29606, (803) 233-2562.

March 19-22

The Eighth Annual Federal Office Systems Expo (FOSE '84), Convention Center, Washington, DC. The theme for this year's expo is "Realities of Integration: Technologies, Applications, Human Resources." More than 60 conference sessions and 1200 exhibits are planned. Address inquiries to Jacqueline Voigt, National Trade Productions, 9418 Annapolis Rd., Lanham, MD 20706, (800) 638-8510; in Maryland, (301) 459-8383.

March 22-23

Computers in Construction, New York, NY. This seminar is designed to assist construction contractors and construction management firms in acquiring computer systems. The fee is $425 per registrant. More details are available from CIP Information Services Inc., 1105-F Spring St., Silver Spring, MD 20910, (301) 589-7933.

a message to our subscribers

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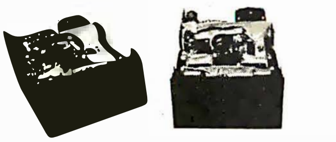
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March 22-25
The Ninth West Coast Computer Faire, Civic Auditorium and Brooks Hall, San Francisco, CA. This is one of the largest annual computer shows. For information, contact the Computer Faire Inc., Suite 201, 181 Wells Ave., Newton, MA 02159, (617) 965-8350; in California, (415) 364-4294.

March 23
The 1984 Computer Law Institute, Cleveland, OH. This event, sponsored by the Bar Association of Greater Cleveland, will cover current legal and tax issues that affect the computer industry. For details, contact Carole Falcone, Mall Building, Cleveland, OH 44114, (216) 696-3525.

March 24
The Seventh Annual Philadelphia Area Computer Society Computer Games Festival, La Salle College Ballroom, Philadelphia, PA. Recreational and educational games will be featured. For more information, contact Dr. Stephen A. Longo, Physics Department, Box 312, La Salle College, Philadelphia, PA 19141, (215) 951-1255.

March 25
The Fifth Annual Lake County Hamfest and Computer Fest, Madison High School, Madison, OH. Admission is $3 in advance. For information, send a self-addressed, stamped envelope to Lake County Hamfest Committee, POB 150, Mentor, OH 44061, (216) 953-9784.

March 26-28
The Seventh International Conference on Software Engineering, Orlando, FL. This conference seeks to evaluate what has been learned from the past and to provide directions for future investigations into software engineering. Its theme is "Fifteen Years of Software Engineering: Results and Futures." A software tools fair will be held concurrently. Contact the IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-3386.

March 26-29
The 1984 National Design Engineering Show & ASME Conference, McCormick Place, Chicago, IL. More than 600 companies will display and demonstrate products and services in this conference program sponsored by ASME (American Society of Mechanical Engineers). Almost 50 technical sessions and 20 short courses will cover engineering management and operations, CAD/CAM and CAE, materials and processes, mechanical and fluid systems, and electronics. Information is available from the National Design Engineering Show & Conference, 708 Third Ave., New York, NY 10017, (212) 661-8410.

March 26-29
Personal Computer Interfacing and Scientific Instrument Automation, Blacksburg, VA. These hands-on workshops, sponsored by the Virginia Polytechnic Institute and State University, provide participants with experience in wiring and testing interfaces on popular personal computers. For information, contact Dr. Linda Leffel, C.E.C., Virginia Tech, Blacksburg, VA 24061, (703) 961-4848.

March 26-30
The Sixth NC Industrial Automation and Robot Conference and Exhibition, Milan Fair, Milan, Italy. Controls for automated material handling, variable mission manufacturing systems, and quality control will be featured. A concurrent conference consisting of 20 sessions will be presented. For more information, contact the Society of Manufacturing Engineers, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-0023.

March 27-28
The Eighth Annual Computer Faire, University of Dayton Arena, Dayton, OH. Terminals, minicomputers, microcomputers, and word processors will be featured. Details can be obtained from Dan Schumacher, University of Dayton, 300 College Park Ave., Dayton, OH 45469, (513) 229-3511.

March 27-28
Meetings of the American National Standards Institute, Marriott Crystal Gateway Hotel, Arlington, VA. Two meetings are planned: the Annual Public Conference of the ANSI and the Seminar on Administering Domestic Standards Activities. The theme for the former is "Standards and the Law." The latter will focus on due process and such issues involved in standardization as the interpretation of standards and coordination of domestic and international activity. Contact Deborah R. Maskin, Communications Department, American National Standards Institute Inc., 1430 Broadway, New York, NY 10018, (212) 354-3315.

March 27-29
Southwest Computer Conference (SWCC), Myriad Convention Center, Oklahoma City, OK. This seventh annual business and industry conference is aimed at both management and technical personnel. It will feature more than 50 seminar presentations and 250 exhibits. For details, contact E. Z. Million, SWCC, POB 950, Norman, OK 73070, (405) 329-3660.

March 28-30
The Sixth Annual Computer Graphics Conference, Doral Hotel On-the-Ocean, Miami Beach, FL. The theme for this conference is "Forecast and Assessments." Further details are available from Carol Sapchin, Frost & Sullivan Inc., 106 Fulton St., New York, NY 10038, (212) 233-1080.

March 30-31
Third Annual Conference on Communication Technology, Joseph Stokes Auditorium, Children's Hospital of Philadelphia, PA. This program presents advances in technology and treatment alternatives for physically disabled and speech-impaired persons. Speakers, equipment demonstrations, and workshops are planned. The two-day registration fee is $95, which includes all course materials. Group rates are offered. For full particulars, contact Joan Bruno, Children's Seashore House, 4100 Atlantic Ave., POB 4111, Atlantic City, NJ 08404, (609) 345-5191, ext. 278.

March 30-April 1
The NY Personal Computer Show, Exposition Rotunda, Madison Square Garden, New York City. Formerly called the Eighty/Apple/PC Computer Show, this event will feature products and services for all small computer systems. Complete show details can be obtained from the Kengore Corp., POB 13, Franklin Park, NJ 08823, (201) 297-2526.

April 1984

April 1-4
The 1984 EFT Expo, Hyatt Regency, Grand Cypress Resort, Orlando, FL. This annual convention and exposition, sponsored by the Electronic Funds Transfer (EFT) Association, provides the op-

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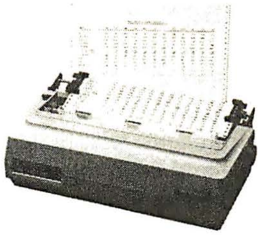
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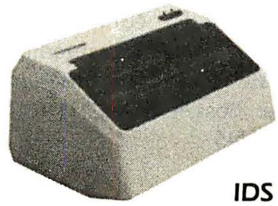
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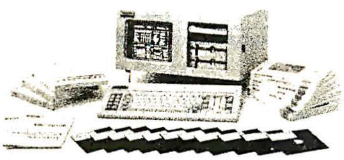
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portunity to meet with leaders and experts in the field of automated payments systems and services. The fee is $495 for EFT members and $625 for nonmembers. For details, contact the Convention Coordinator, EFT Association, Suite 800, 1029 Vermont Ave. NW, Washington, DC 20005.

April 2–4
Speech Tech–84, St. Moritz Hotel, New York City. This voice-synthesis and recognition applications show covers voice input/output as applied to computers, telecommunications, defense electronics, robotics, education, and aids for the handicapped. The registration fee is $150. For information, contact Stanley Goldstein, Media Dimensions Inc., 525 East 82nd St., New York, NY 10028, (212) 680-6451.

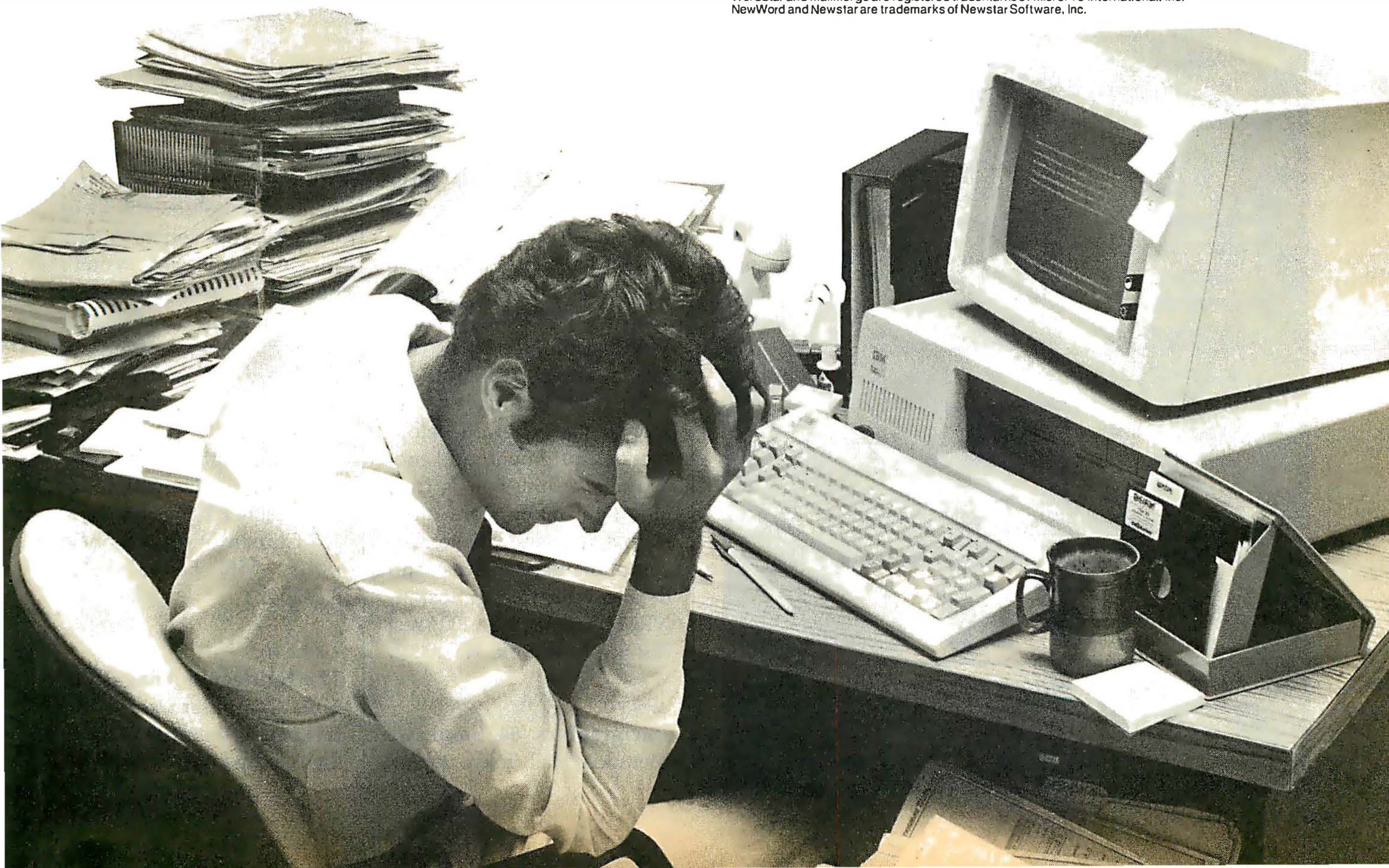
April 2–5
The 1984 Test & Measurement World Expo, Brooks Hall, San Francisco, CA. This is the third annual expo sponsored by *Test and Measurement World*, a magazine from Interfield Publishing. For details, contact Meg Bowen, Test & Measurement World Expo, 215 Brighton Ave., Boston, MA 02134, (617) 254-1445.

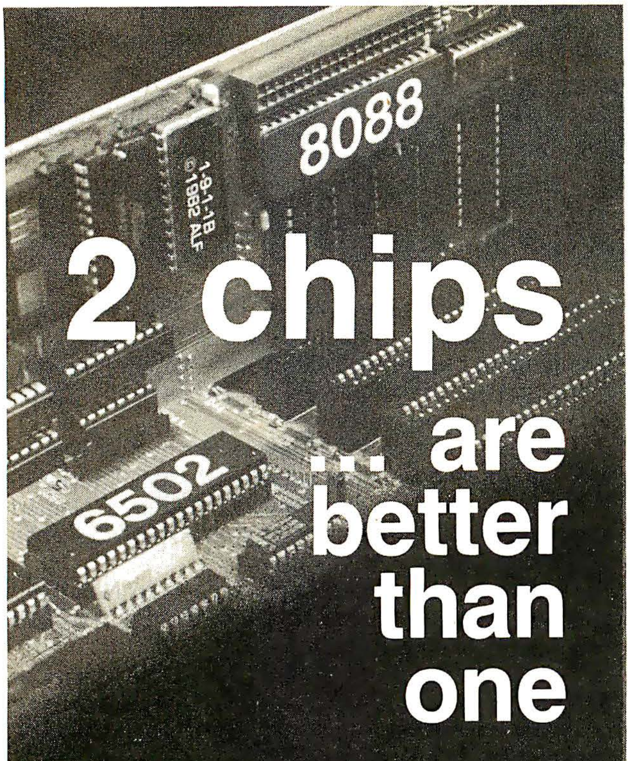
April 2–6
The Third Conference on Computing in Civil Engineering, Holiday Inn at the Embarcadero, San Diego, CA. Seminars, tutorials, and vendor displays will focus on computers in education, special applications, and future directions. Emphasis will be on computer-aided design and drafting. Complete conference particulars are available from the Society for Computer Applications in Engineering, Planning, and Architecture Inc., 358 Hungerford Dr., Rockville, MD 20850, (301) 762-6070.

April 3–5
Cincinnati Business Show, Convention-Exposition Center, Cincinnati, OH. Exhibits include automated office equipment, computers, communications, telephone systems and equipment, word processors, business systems and forms, and software and computer peripherals. For information, contact Weber and Associates Inc., 10608 Millington Court, Cincinnati, OH 45242, (513) 791-6303.

April 3–6
DEXPO East 84, Bayside Exposition Center, Boston, MA. This conference, dedicated to professionals who use Digital Equipment Corporation (DEC) equipment, is sponsored by the national independent DEC user group of Warwick, Rhode Island. Topics to be covered are office automation, personal computers, communications, security and disaster planning, education, graphics, technology trends, and other areas of interest. For information, contact Expoconsul International Inc., 55 Princeton-Hightstown Rd., Princeton Junction, NJ 08550, (609) 799-1661.

April 4–6
Introduction to Computers and Their Applications, Pinehurst Hotel and Country Club, Chapel Hill, NC. This educational workshop is designed for professionals and executives. For a brochure, contact Learning at Pinehurst, POB 2328, Chapel Hill, NC 27514, (919) 967-6996.





Event Queue

April 4–11
CeBIT, Hannover, West Germany. This office-equipment and data-processing technology exhibition will bring together exhibitors from more than 25 countries. For information, contact Hannover Fairs Information Center, POB 338, Route 22 E, Whitehouse, NJ 08888, (800) 526-5978; in New Jersey, (201) 534-9044.

April 5–7
COMDEX/Winter, Convention Center, Los Angeles, CA. For information, contact the Interface Group Inc., 300 First Ave., Needham, MA 02194, (800) 325-3330; in Massachusetts, (617) 449-6600.

April 7–8
Eastern States Conference, Franklin Plaza Hotel, Philadelphia, PA. Speakers, demonstrations, and workshops focusing on "Computers and Reading/Learning Difficulties" are planned. For additional information, contact Educational Computer Conferences, Department N, 1070 Crows Nest Way, Richmond, CA 94803, (415) 222-1249.

April 8–11
World Retailers Business & Equipment Exposition, Palais des Congres, Paris, France. This exposition is sponsored by the National Retail Merchants Association (NRMA) and runs concurrently with NRMA's Ninth World Conference of Retailers. The exposition is designed to introduce store merchants to new developments, equipment, and procedures. Admission is free, although retail store merchants must show ticket. For complimentary tickets and details, write to Dan Soskin, NRMA Enterprises, 100 West 31st St., New York, NY 10001.

April 9–12
Intergraphics '84, Sasakawa Memorial Hall, Tokyo, Japan. This conference and exposition is cosponsored by the Society of Manufacturing Engineers (SME) and the World Computer Graphics Association (WCGA). It will focus on the growing importance of computer graphics in business and manufacturing industries. For information, contact James McLaughlin, Society of Manufacturing Engineers, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-0023.

April 10–11
Business Expo & Conference '84, Convention Center, San Jose, CA. More than 30 workshops, seminars, and panel discussions have been scheduled. A few of the presentations are "Handling Training Crisis in Office Automation Explosion," "How to Select Small Business Computers," and "Managing Your Small Business." Complete details are available from Expo '84 Management, Cartlidge & Associates Inc., Suite 205, 4030 Moorpark Ave., San Jose, CA 95117, (408) 554-6644.

April 12–14
Computers and Writing—Research and Applications, University of Minnesota, Minneapolis. Papers and panel discussions will focus on local-area networks, empirical studies of writer's behavior, and automatic evaluation or correction of writing. Demonstrations of hardware and software are planned. For further information, contact the Program in Composition and Communication, University of Minnesota, 209 Lind Hall, 207 Church St. SE, Minneapolis, MN 55455, (612) 373-2541.

April 13–14
The Fourteenth Annual Virginia Computer User's Conference, Sheraton Hotel, Blacksburg, VA. This con-

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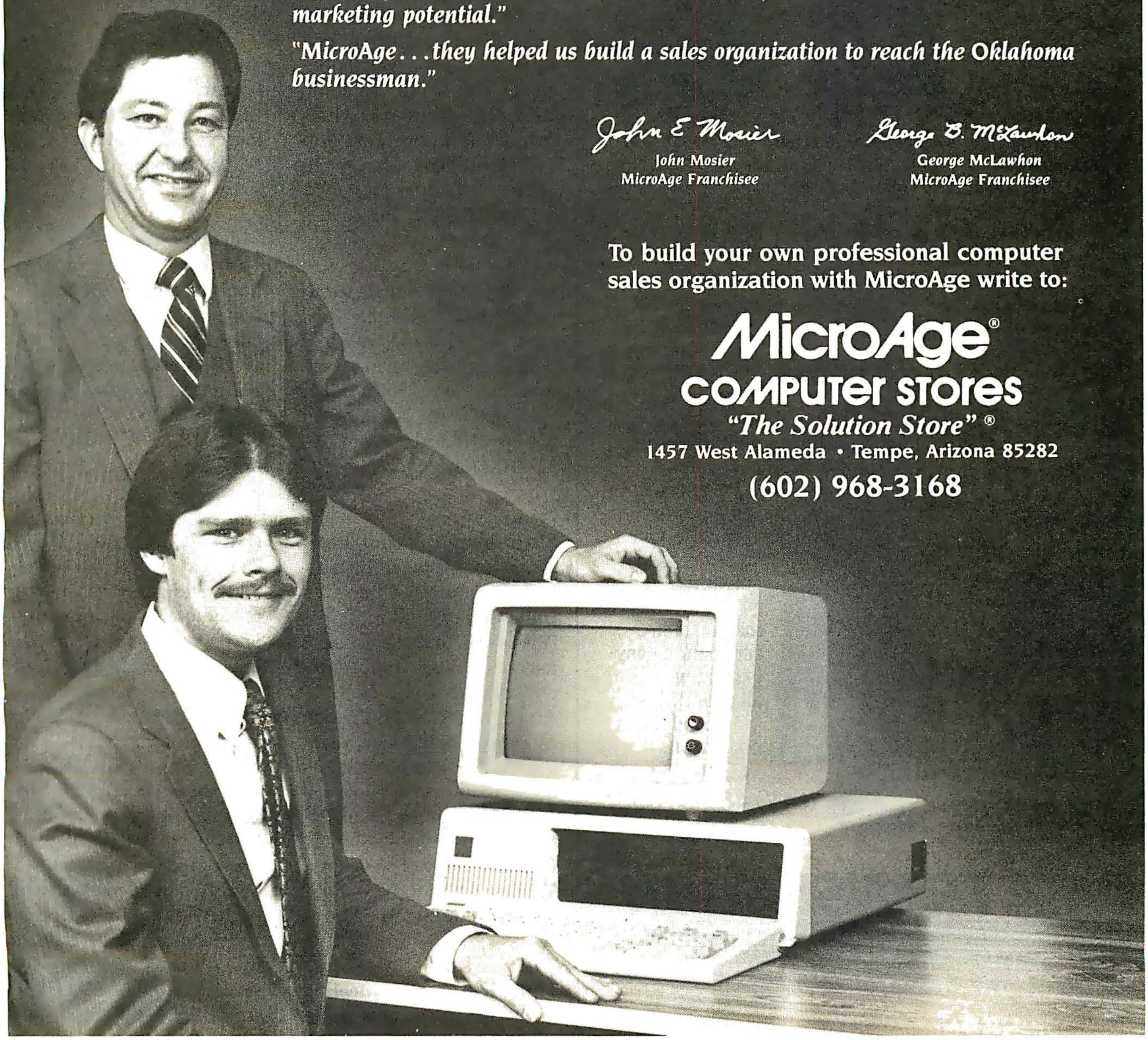
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ference is sponsored by the Virginia Tech Student Chapter of the ACM (Association for Computing Machinery) and the computer science department of Virginia Tech. Topics include modeling and simulation, STARS and Japanese fifth-generation computers, and microcomputers. For information, contact Suzanne Nagy or Roger Goff, VCUC-14, 562 McBryde Hall, Virginia Tech, Blacksburg, VA 24061.

April 13–15
The International Personal Robotics Congress and Exposition, Convention Center, Albuquerque, NM. International corporations and high-technology executives can view the latest in robots designed to serve personal needs. For details, contact Albuquerque Convention and Visitors Bureau Inc., POB 26866, Albuquerque, NM 87125-6866, (505) 243-3696.

April 13–15
Interstellar Personal Computer Show, Interstate Fairgrounds, Spokane, WA. For details, contact Heymac Promotions, East 3607 33rd, Spokane, WA 99203, (509) 534-3661 (mornings) or (509) 327-4842 (afternoons).

April 13–15
Microcomputers and Basic Skills in College, Instructional Resource Center, City University of New York, NY. Papers will explore the use of microcomputers in post-secondary school basic-skills instruction, including English as a second language, reading, writing, and speech. Address inquiries to Geoffrey Akst, Conference Chair, Instructional Resource Center, City University of New York, 535 East 80th St., New York, NY 10021, (212) 794-5425.

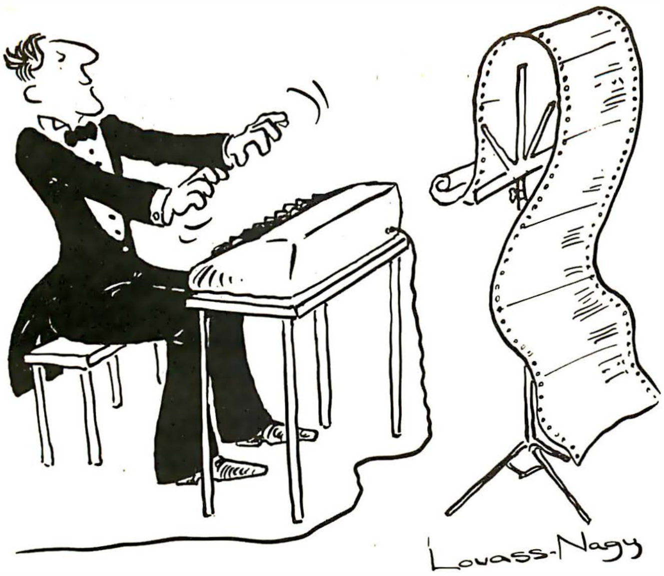
April 14
Third Semi-annual Meeting of the Massachusetts Association of Computer-using Educators, Simmons College, Boston, MA. This meeting will feature demonstrations on the uses of computers in the classroom. Contact Dr. Leonard Huber, Hampshire Educational Collaborative, Center School, 36 Hadley St., South Hadley, MA 01075, (413) 534-4563.

April 14–15
The Ninth Annual Trenton Computer Festival, Trenton State College, NJ. More than 100 commercial exhibitors will complement five acres of flea-market tables. Contact Marilyn Hughes, Trenton State College, Trenton, NJ 08625, (609) 771-2487.

April 16–18
Softside of Software, Loew's L'Enfant Plaza Hotel, Washington, DC. For details, see March 12-14.

April 16–18
Videotex '84, Chicago, IL. The focus of this international conference and exhibition is commercial applications and activities of videotex. For details, contact Sally Summers, London Online Inc., Suite 1190, 2 Penn Plaza, New York, NY 10121, (212) 279-8890.

April 17–19
IPAD II, Marriott Hotel, Denver, CO. This is the second national symposium to promote a wider awareness of the technology surrounding the Integrated Program for Aerospace-vehicle Design (IPAD). The focus will be on advances in distributed database management technology to support integrated CAD/CAM requirements. It is sponsored by the National Aeronautics and Space Administration, the Department of the Navy, and the Industry Technical Advisory Board for IPAD. Information is available from the IPAD Project Office, Mail Stop 246,



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•XASM85	8085		
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XASM09	6809		
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XASM51	8051	$200.00 each	
XASM65	6502		
XASM68	6800/01		
XASMZ8	Z8		
XASMF8	F8/3870		$300.00 each
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XASM75	NEC 7500	$500.00	
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NASA Langley Research Center, Hampton, VA 23665, (804) 865-2888.

April 18-19
Minnesota Office Systems Association Symposium and Exhibition, Hyatt Regency, Minneapolis, MN. Speakers, more than 100 exhibits, and 21 seminars will highlight this eleventh anniversary event focusing on "Evolving Technologies." Further information is available from the Minnesota Office Systems Association, POB 2144, Loop Station, Minneapolis, MN 55402-0144, (612) 293-1395.

April 18-20
The 1984 Rocky Mountain Data Processing Expo & Conference, Denver, CO. This is the seventh annual expo sponsored by the Mile High Chapter of the Data Processing Management Association. Displays will include mini- and microcomputers, word processors, software, educational services, and network systems. It is being held in conjunction with the DPMA's Region 4 conference. For information, contact Industrial Presentations West Inc., Suite 304, 3090 South Jamaica Court, Aurora, CO 80014, (303) 696-6100.

April 23-27
Auditing in the Contemporary Computer Environment, Philadelphia, PA. For details, see March 12-16.

April 24-25
Workspace 84, Moscone Center, San Francisco, CA. This second annual conference and exposition, sponsored by National Fairs Inc., will be devoted to the concerns of the automated office. For details, contact Charley Yourd, National Fairs Inc., 1902 Van Ness Ave., San Francisco, CA 94109.

April 26-28
Science Park '84, New Haven, CT. This microcomputer conference and exposition is designed for small-business executives. For details, contact Science Park '84, Five Science Park, New Haven, CT 06511, (203) 436-3089.

May 1984

May-July
Courses from Integrated Computer Systems, various sites throughout the U.S. Among the courses to be presented are "Designing with 16-bit Micros," "Programming in C: A Hands-on Workshop," and "Hands-on Unix Workshop." The fee for each course is $895. Enrollment details are available from Ruth Dordick, Integrated Computer Systems, 6305 Arizona Place, POB 45405, Los Angeles, CA 90045, (213) 417-8888.

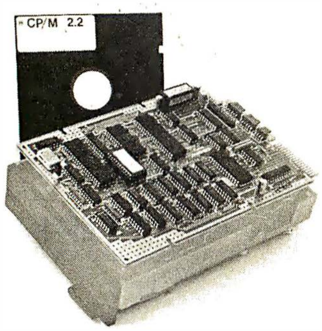
May 1-3
Electronic Production Efficiency Exposition, National Exhibition Centre, Birmingham, England. This exhibition brings together various organizations involved in producing hardware and software for automated factories. Technical sessions will cover such issues as computer-aided design and manufacturing, integration, test diagnosis and repair systems, and electronic-manufacturing assembly techniques. Contact Network Events Ltd., Printers Mews, Market Hill, Buckingham, MK18 1JX, England; tel: (0280) 815226; Telex: 83111.

May 4-6
The Serious Computer Show, Curvigan Hall, Denver, CO. Conference topics include "Reducing Information Storage Costs Through Micrographics," "Software Integration for the '80s," and "The Law as It Relates to the Computer World." Microcomputers, peripherals, services, accessories, and supplies will be exhibited. For complete particulars, contact Industrial Presentations West Inc., Suite 304, 3090 South Jamaica Court, Aurora, CO 80014, (303) 696-6100.

May 5
The Sixth Annual Computer Conference for Educators, Lesley College, Cambridge, MA. Panel discussions, more than 20 presentations, and sessions that include hands-on workshops on software in science, social science, language arts, and mathematics will be offered. Additional information is available from Susan Friel or Nancy Roberts, Lesley College, 29 Everett St., Cambridge, MA 02238, (617) 868-9600.

May 7-9
EDP Audit, Controls, and Security Symposium, Woodfield Hyatt House, Woodfield, IL. This symposium provides seminars, workshops, and exhibits relating to the state of the art in electronic data-processing auditing. Address inquiries to EDP Audit Associates Inc., POB 255, Chicago Ridge, IL 60415, (312) 582-4622.

May 7-11
Tutorials for Professional Development, Marriott O'Hare, Chicago, IL. Two tracks, "Software Engineering" and "Networks and Communications," compose this program sponsored by the IEEE Computer Society and the Association for Computing Machinery. For a copy of the program, contact Tutorials for Professional Development, POB 639, Silver Spring, MD 20901, (301) 589-8142.



May 9–11
Session 84, Calgary, Alberta, Canada. This is the annual national conference of the Canadian Information Processing Society. The theme is "1984: Images of Fear, Images of Hope." Parallel seminars, panel discussions, technical papers, and exhibits of hardware, software, and services will assist in the exchange of views between users and suppliers. Conference information can be obtained from Ms. Marilyn Harris, Suite 722, Suncor Tower, 500 4th Ave. SW, Calgary, Alberta T2P 2V6, Canada, (403) 261-5903.

May 12–14
Softwest '84, Regency Hotel and Conference Center, Denver, CO. This conference and exhibition features seminars, lectures, and panel discussions on software, equipment, and peripherals for Apple and IBM computers. For information, contact Colorado Conference Group, Suite C, 3312 Cripple Creek, Boulder, CO 80303, (303) 499-1034.

May 13–17
Computer Graphics '84, Convention Center, Anaheim, CA. This is the fifth annual conference and exposition sponsored by the National Computer Graphics Association (NCGA). For details contact the NCGA, 8401 Arlington Blvd., Fairfax, VA 22031, (703) 698-9600.

May 14–16
Annual Conference of ADCIS, Ohio State University, Columbus. This annual conference is sponsored by the Association for the Development of Computer-based Instructional Systems (ADCIS). Papers and demonstrations of hardware, software, and courseware will emphasize portability. For details, contact ADCIS International Headquarters, 409 Miller Hall, Western Washington University, Bellingham, WA 98225, (206) 676-2860.

May 15–17
Criminal Justice Systems Conference, Virginia Commonwealth University, Richmond, VA. Presentations and panel discussions on recent developments in criminal justice applications of computer technology are planned. Additional sessions will address the uses of microcomputers in law enforcement. The fee is $20. Information is available from Ben Wood, Department of Criminal Justice Services, 805 East Broad St., Richmond, VA 23219, (804) 786-4000.

May 15–17
Micro City '84, Exhibition Complex, Bristol, England. More than 100 companies will exhibit computers, business systems, and communications equipment. For complete details, contact Tomorrow's World Exhibitions Ltd., 9 Park Place, Clifton, Bristol BS8 1Jp, England; tel: (0272) 292156/7.

May 16–18
Teaching Math with Microcomputers, Marriott Hotel, Miami, FL. This program, sponsored by the National Council of Teachers of Mathematics (NCTM), is designed to inform elementary, intermediate, and secondary school teachers of mathematics how to effectively use the microcomputer as a classroom tool. For further information, contact NCTM, 1906 Association Dr., Reston, VA 22091, (703) 620-9840.

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May 19
The Seventh Annual Show & Tell Microcomputer Conference, University of Oklahoma Mathematics and Physical Science Complex, Norman, OK. Computer hobbyists are invited to speak briefly, demonstrate an example of their presentation, and answer questions in a Show & Tell period. For details, send a self-addressed, stamped envelope to Show & Tell, Dr. Richard Andree, University of Oklahoma, Mathematics Department, 601 Elm St., Norman, OK 73019.

May 20–23
The Thirteenth Mid-Year Meeting of the American Society for Information Science, Indiana University, Bloomington. The theme for this meeting is "The Micro Revolution: Implications for the Information Age." Joseph Weizenbaum, author of *Computer Power and Human Reason* and a computer science professor at MIT, will speak. For more information, contact Stephen Harter, School of Library and Information Science, Indiana University, Bloomington, IN 47405, (812) 335-5113.

May 20–25
The Fourth Jerusalem Conference on Information Technology—JCIT, Jerusalem, Israel. Papers, panel discussions, workshops, and exhibits will emphasize software engineering and manufacturing related to the theme of this international event, the "Next Decade in Information Technology." Until April 30, the registration fee is $200. After that date, the fee is $225. Isratech '84, the national exhibition of high technology, runs concurrently with JCIT. For information on Isratech '84, contact the Government of Israel Trade Center, 350 Fifth Ave., New York, NY 10118, (212) 560-0660. For details on JCIT, contact the Fourth Jerusalem Conference on Information Technology, POB 29313, 61292 Tel Aviv, Israel; tel: (03) 258-535.

May 21–23
AAMSI Congress 1984—The Third Spring Joint National Congress, Hilton Hotel, San Francisco, CA. Invited and contributed papers, special sessions, tutorials, reviews, panel discussions, and demonstrations will explore the applications of computers and information technology and systems to all fields of medicine. A dozen professional organizations have joined the American Association for Medical Systems and Informatics (AAMSI) as program sponsors. For particulars, contact AAMSI, Suite 402, 4405 East-West Highway, Bethesda, MD 20814, (301) 657-4142.

May 22–25
COMDEX/Spring, Georgia World Congress Center, Atlanta. For details, contact the Interface Group, 300 First Ave., Needham, MA 02194, (800) 325-3330; in Massachusetts, (617) 449-6600.

May 22–26
Oficomp Korea 84—The International Korean Office and Information Management Exhibition and Conference, Korea Exhibition Center, Seoul, South Korea. Exhibits will include demonstrations of computers, communications equipment, and business machines. Contact Clapp & Poliak International, POB 70007, Washington, DC 20088, (301) 657-3090.

May 23–24
Automach-Australia '84, Royal Hall of Industries Showground, Sydney. This trade show serves to update Australian manufacturing industries on automated, integrated factory systems incorporating numerically controlled machinery, CAD/CAM, and robotics. Contact SME World Headquarters, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-1500. In Australia, contact Mr. Greco, Howard Rotavator Pty., POB 82, Parramatta 2150, New South Wales, Australia; tel: 630-1231; Telex: AA21328.

May 23–24
The 1984 Trends and Applications Conference, National Bureau of Standards, Gaithersburg, MD. Presentations will address current systems and applications as well as research into advanced concepts relating to the theme, "Making Database Work." Information can be obtained from Trends and Applications 84, POB 639, Silver Spring, MD 20901, (301) 921-3491.

May 23–25
The Eighth Conference on Computer Applications in Radiology, Stouffer's Riverfront Towers, St. Louis, MO. Patient information systems, personal computers and computers for the private office, teleradiology, computer-assisted instruction, and artificial intelligence are a few of the topics to be covered. Exhibits are included. The fee is $350. For details, contact American College of Radiology, 20 North Wacker Dr., Chicago, IL 60606, (800) 227-5463; in Illinois, (312) 236-4963.

May 23–25
The Third Annual European Semiconductor Industry Conference, Hotel Kempinski, Berlin, West Germany. International industry leaders will discuss issues facing the semiconductor industry. Contact Barbara Chupp, Dataquest Inc., 1290 Ridder Park Dr., San Jose, CA 95131, (408) 971-9000.

May 29–31
Gulf Coast Computer and Office Show, New Orleans, LA. Speakers, technical sessions, and product displays will highlight this exhibition. For full details, contact Gulf Coast Computer and Office Show, 119 Avant Garde Circle, Kenner, LA 70062, (504) 467-9949.■

In order to gain optimal coverage of your organization's computer conferences, seminars, workshops, courses, etc., notice should reach our office at least three months in advance of the date of the event. Entries should be sent to: Event Queue, BYTE Publications, POB 372, Hancock, NH 03449. Each month we publish the current contents of the queue for the month of the cover date and the two following calendar months. Thus a given event may appear as many as three times in this section if it is sent to us far enough in advance.

BYTE's Bits

Call for Papers

The conference chairperson for COMPCON Fall 1984 (September 16-19, Hyatt Regency Crystal City, Arlington, VA) has issued a call for papers on the theme "The Small Computer (R)evolution." Suitable topics include user friendliness, embedded systems, and the architecture of small computer applications and products. Send three copies of your 1000- to 5000-word paper to Joe Batz, Small Computer (R)evolution, POB 639, Silver Spring, MD 20901, before April 2.■

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—Use it as an IBM PC look alike that directly boots PC DOS 1.1 and accepts all expansion boards designed for the IBM PC.
—Use it as a powerful 8088 single board computer for all your OEM applications. Just add serial terminal, disk drive and power supply. Directly boots CP/M-86.

Buy the MPX-16 in the form that best meets your needs or budget. As a bare board, as a wave soldered board that contains *all* components *less* ICs, as an assembled and tested circuit board or as a complete system.

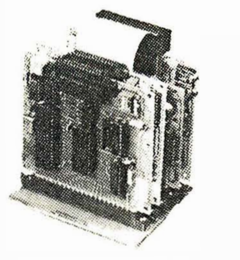
- Directly boots PC DOS 1.1 and CP/M-86.
- Most IBM PC software executes with no modifications.
- IBM PC bus compatible + 9 expansion slots.
- Intel 8088 16-bit microprocessor.
- Optional Intel 8087 math coprocessor.
- 256K bytes on board memory.
- Up to one megabyte of system memory.
- Up to 64K bytes of system ROM/EPROM.
- 2 RS-232C Serial & 3 Parallel I/O ports.
- Disk controller for 5¼" or 8" drives.
- Sixteen levels of vectored interrupts.

MPX-16 Circuit Board Assembled
w/64KRAM .... $1,200.
OEM100 quantity price .... 900.
MPX-16 Circuit Board Asembled
w/256KRAM .... 1,400.
***MPX-16 Semi-Kit (wave soldered circuit* board w/all components) Less ICs ..... 595.**
Complete Kit of ICs w/256K RAM .... 595.
MPX-16 Unpopulated (bare) PC Board .... 300.
CP/M-86 Operating System + Manuals ... 80.
MPX-16 Switching Power Supply .... 300.
MPX-16 Technical Reference Manual ..... 50.
MPX-16 Metal Enclosure with Fan .... 300.
Tandon TM 100-2 Double Sided/Density Drive .... 300.
IBM PC Keyboard Interface Adapter ...... 100.
Shipping & handling additional on all MPX-16 orders.

IBM PC is a trademark of International Business Machines Inc.
CP/M-86 is a trademark of Digital Research Inc.
Z8 is a trademark of Zilog Inc.

Circle 240 on inquiry card.

Z8 BASIC SYSTEM CONTROLLER NEW!!!



As featured *in Ciarcia's Circuit Cellar. BYTE Magazine, July & August 1981*

The Z8 Basic System Controller is an updated version of our popular BCC01. The price has been reduced and features added. The entire computer is 4" by 4½" and includes a tiny BASIC interpreter, up to 6K bytes of RAM and EPROM, one RS-232C serial port with switchable baud rates and two parallel ports. BASIC or machine language programming is accomplished simply by connecting a CRT terminal. Programs can be transferred to 2732 EPROMs with an optional EPROM programmer for auto start applications. Additional Z8 peripheral boards include memory expansion, serial and parallel I/O, real time clock, an A/D Converter and an EPROM programmer.

- Uses Zilog Z8 single chip microprocessor.
- Data and address buses available for 124K memory.
- Can be battery operated.
- Cross assemblers for various computers.

***BCC11* Assembled & Tested .... $149.**
New Low Price

Z8 MEMORY. I/O EXPANSION. CASSETTE INTERFACE

- 8K bytes of additional RAM or EPROM.
- Three additional 8 bit parallel ports.
- Cassette interface—300 baud K.C. Standard.
- Software real time clock.

BCC03 w/4K RAM Assembled & Tested ..... $150.
BCC04 w/8K RAM Assembled & Tested ..... 180.

Z8 EPROM PROGRAMMER

- Transfer BASIC or Assembly Language application programs from RAM to 2716 or 2732 EPROM.
- Comes with programming & utility routines on EPROM.
- Requires BCC03 Z8 Expansion Board for operation.

BCC07 Assembled & Tested .... $145.

Z8 ANALOG TO DIGITAL CONVERTER

- Uses Analog Devices 7581 IC, 8-channel 8-bit.
- Adds process control capability to the Z8 system
- Over 1,000 conversions per channel per second.
- Monitors 8 analog signals in one of two 10v ranges.

BCC13 Assembled & Tested .... $140.

Z8 SERIAL EXPANSION BOARD

- Adds additional RS-232C and opto-isolated 20 ma. current loop serial port to the Z8 System.
- Runs at 75 to 19,200 baud in all protocols.
- Comes with listings of sample serial I/O routines.

BCC08 Assembled & Tested .... $160.

Z8 16K MEMORY EXPANSION BOARD

- Add up to 16K of additional memory, RAM or EPROM, to your Z8 System Controller in any multiple.
- Accepts 2016, 6116, 2716, or 2732 memory types.
- Four 16K cards may be installed on the Z8 System bringing the total memory to 64K.

BCC14 Assembled & Tested w/8K RAM ..... $120.
BCC16 Assembled & Tested w/16K RAM ..... 155.

COMING SOON! FORTH LANGUAGE VERSION OF THE Z8

With the new Z8 with on board 4K FORTH you can program high speed control functions in a few simple high level language commands. Perfect for data reduction, process control and high speed control applications.

BCC20 Z8F FORTH Microprocessor chip .... $150.
BCC21 Z8F FORTH System Controller
(This board is a BCC11 with a BCC20 installed)
Assembled & Tested .... 280.

Z8 CROSS ASSEMBLERS

From Micro Resources
IBM PC, APPLE, 6502 Systems 5¼",
CP/M 2.2 8" .... $ 75.
From Allen Ashley
TRS-80 Model I, III, Northstar 5¼" .... 75.
CP/M 2.2 8" .... 150.

Z8 FIVE SLOT MOTHER BOARD

- Expand your Z8 BASIC System with minimum effort.
- Contains five slots complete w/44 pin connectors.

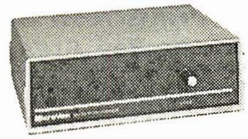
MB02 Assembled & Tested .... $69.

TRIPLE VOLTAGE POWER SUPPLIES

+5V @ 300 ma. +/−12V @ 25 ma.
UPS01 Assembled & Tested .... $35.
UPS02 Complete Kit .... 27.
+5V @ 1 Amp. +12V @ .5 Amp. −12V @ 50 ma.
UPS03 Assembled & Tested .... 60.
UPS04 Complete Kit .... 50.

SPEECH SYNTHESIZERS

MICROVOX TEXT-TO-SPEECH SYNTHESIZER



As featured *in Ciarcia's Circuit Cellar BYTE Magazine September, October 1982.*

Microvox is a second generation professional voice quality text-to-speech synthesizer that is easily interfaced to any computer, modem, RS-232C serial or parallel output device and provides speech of unbelievable clarity.

- Unlimited vocabulary.
- 64 programmable inflection levels.
- 6K text-to-speech algorithm.
- Full ASCII character set recognition and echo.
- RS232C and parallel output.
- 1000 character buffer, 3000 optional.
- Adjustable baud rates (75-9600)
- Spelling output mode.
- 7 octave music and sound effects.
- On board audio amplifier & power supply.
- X-On/X-Off handshaking.

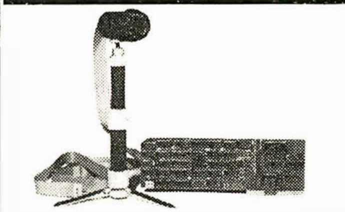
MV01 Assembled with 1K buffer .... $299.
MV02 Complete Kit with 1K buffer .... 219.
Add $15.00 for 3K buffer option.

VOTRAX SC-01A PHONETIC SPEECH SYNTHESIZER IC

The SC-01A Speech Synthesizer is a completely self-contained solid state device that phonetically synthesizes continuous speech of unlimited vocabulary. Used in our Microvox and Sweet-Talker.

SC01A Quantity 1–99 .... $44. ea.
100 + ... 32. ea.
1000 + ... 24. ea.

MICRO D-CAM DIGITAL TV CAMERA



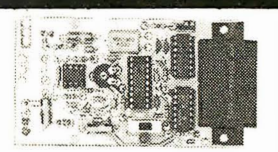
As featured in Ciarcia's Circuit Cellar BYTE Magazine. September & October 1983

GIVE YOUR COMPUTER THE DIMENSION OF SIGHT

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- Software includes utilities for auto exposure, multi-level greyscale, screen dump and image enhancement.
- Includes interface card, 4 foot extension cable, camera assembly, manual, and software on diskette.

DC01 IBM PC Assembled & Tested .... $299.
DC02 IBM PC Complete Kit .... 264.
DC03 APPLE II Assembled & Tested .... 299.
DC04 APPLE II Complete Kit .... 264.

300 BAUD ANSWER/ ORIGINATE MODEM KIT



As featured in Ciarcia's Circuit Cellar BYTE Magazine, March 1983

Micromint's latest 300 Baud Modem Kit is crystal controlled, uses the TI TMS99532 IC, contains just 25 parts and requires no calibration or adjustments. Use with acoustic coupler or in direct connect mode.

MD04 Complete Kit as shown .... $60.
MD05 Transformer for Direct Connect Mode .. 9.
AC01 Acoustic Coupler Kit .... 20.

E-Z COLOR GRAPHIC INTERFACE WITH SPRITES

APPLE II E-Z Color plug-in board with Graphics Editor on 3.3 disk
EZ01 Assembled & Tested .... $150.
EZ02 Complete Kit .... 125.

APPLE II E-Z Color Plus
- Allows the use of a single monitor or TV set.

EZ11 Assembled & Tested w/Graphics Editor . $200.

KRELL LOGO for E-Z Color and E-Z Color Plus
Supports Sprite Graphics.
EZ21 Krell LOGO w/full documentation .... $89.

Animation Software for E-Z Color Plus
- Draw with Sprites using Joystick or Koala Pad.
- Animate Sprites from your own BASIC program.

EZ21 Animation Software .... $49.

S100 E-Z Color Graphics Board
- With sound generator & joystick interface.
- MBASIC Graphics Editor on 8" diskette

EZ04 Assembled & Tested .... $289.

***MICROMINT INC.** 561 Willow Avenue, Cedarhurst, NY 11516*
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***For Information Call:** 1-516-374-6793*
Call: Monday-Friday, 9-5 PM

MICRO MINT

Clubs and Newsletters

Visitors Welcome in Atlanta

The Atlanta IBM-PC Users Group, a nonprofit corporation that assists users of the IBM Personal Computer and similar personal or desktop computers, welcomes visitors to its monthly meetings. General meetings are held the second Wednesday of every month at 7:30 p.m. and business-users meetings convene at the same time on the third Wednesday of every month. The club maintains a software library, a bulletin board, and a monthly newsletter, *Atlanta PC News.* A discount is offered to members at local computer stores. Annual dues are $20 a year. For details, contact the Atlanta IBM-PC Users Group Inc., POB 76516, Atlanta, GA 30358, or call Will Macoy at (404) 433-4500.

Windy City Atarians

Suburban Chicago Atarians (SCAT) is an independent computer users group that meets on the first Saturday of each month at 11 a.m. A monthly newsletter containing articles, minutes of the meetings, and programs is produced. Membership is $15 annually, which includes a subscription to the newsletter. Write to SCAT, POB 72266, Roselle, IL 60172.

A Real Network

The Real Estate Information Network Inc. (REINET) provides programs and other information for real estate professionals, appraisers, investors, syndicators, brokers, property managers, and attorneys. It supports various newsletters, a financial database, current sales and rental data, and other items of interest for realty professionals. REINET takes special interest in the TRS-80 Model 100. A quarterly publication, *REINFO,* is produced. Membership requires a one-time connect charge of $100; the hourly rate is $4.50. For membership information, send a self-addressed, stamped envelope to REINET, POB 257, Nyack, NY 10960, or call Compuserve 72235,301.

Over Hill, Over Dale

Field Portable Computing, an independent quarterly newsletter produced by Breakthrough Inc., contains product reviews, industry trends, analyses, and information of interest to both users and manufacturers of battery-operated briefcase-style computers. Single issues are $15; an annual subscription is $48. For details, contact Breakthrough Inc., POB 230, Logan, UT 84321, (801) 753-7555.

Printscreen in the Bay Area

The Stanford/Palo Alto Users Group for the IBM PC meets at 7 p.m. on the last Wednesday of every month. The monthly newsletter, *PrtSc,* is free with an annual $25 membership. For information, write to Linda de Sosa, POB 3738, Stanford, CA 94305, or call (415) 856-6281.

The Cottage Industry

Cottage Computing, a monthly publication from Home Business News, contains the latest information on computer-based businesses, book and software reviews, and business techniques. It contains bulletin-board listings, an education column, product briefs, classified advertisements, and events. Nontechnical articles and paid advertising are accepted. Single issues are $1 and subscriptions are $12 a year. For information, contact Home Business News, 12221 Beaver Pike, Jackson, OH 45640.

An Original Eye Opener

The Original Apple ///rs is a nonprofit organization that meets at 7:30 p.m. on the third Wednesday of each month in San Francisco. The newsletter, *Open Apple Gazette,* is produced monthly and contains articles on important points about the Apple III. Annual membership is $30. Further details are available from Original Apple ///rs, 1850 Union St. #494, San Francisco, CA 94123.

Model 100 Club in Britain

Users of the TRS-80 Model 100 in England have formed a club to ensure the machine's capabilities are realized. A quarterly newsletter is planned. An annual subscription is £12. Send a self-addressed envelope for details to REMSOFT, 18 George St., Brighton BN2 1RH, England.

Apples in Oak Ridge

Users of Apple, Franklin, and compatible computers are welcome to join a club in Oak Ridge, Tennessee, that meets to exchange knowledge, skills, and software in the areas of members' interests. An annual membership is $15. For details, contact the Computer & Program Exchange Club (CAPEC DEP-D), POB 1142, Oak Ridge, TN 37831.

Dues for News or Floppies

The Robin Owners Group is a nonprofit group dedicated to spreading information to owners and users of the DEC Robin (VT180). A newsletter is produced and costs $2 for every four issues. Floppy disks containing public-domain software are $2 and include a formatted disk. For details, contact John Comella, 2 Mockingbird Lane, Maynard, MA 01754.

Mother Hubbard Invites Women

The Mother Hubbard Users Group meets every month, alternating between mornings and evenings to allow all members to participate. This women's user group is designed to introduce computer novices to the uses of the Apple computer. Meetings are free and are held either in the Long Beach/West Orange County area of California or at CompuKids Inc. in Seal Beach. For details, contact Dory Spencer at (213) 438-5643 or Mary Kay Toumajian at (213) 597-6330, or write to CompuKids Inc., Rossmoor Shopping Center, 12385 Seal Beach Blvd., Seal Beach, CA 90740, (213) 430-7226.

C-64 Users of the South Bay

The South Bay Commodore 64 Users Group meets on the second and fourth Tuesdays of each month to discuss problems, programs, and hardware. Classes and

seminars are offered and a monthly newsletter is planned. For details, contact the South Bay Commodore 64 Users Group, POB 3193, San Ysidro, CA 92073.

North American Readout

The North American Computer Service Association (NAC/SA) is composed of charter memberships by participating companies and corporations. NAC/SA promotes the development of computer maintenance, services, and industry. The group offers courses, conducts surveys, sponsors conferences, and produces a newsletter entitled *Readout*. Associate member dues for corporations are based on the size of the company; a flat rate is available for individuals and educational institutions. For additional information, contact David Glascock, NAC/SA, 227 North Magnolia #202, Orlando, FL 32801, (305) 442-2000.

Virginia's Technical Network

CPro Users Group, a national users group for owners and users of Godbout's Compupro, is designed for technical people to share information, solutions, and applications. A monthly newsletter is produced, a bulletin board is maintained, and publication of the member list is anticipated. Membership is $10. For details, contact Curt Hess, CPro Users Group, POB 1474, Woodbridge, VA 22193, (703) 690-3312.

What You Can Do For Your Club

The Society of Pet Handlers for Information Exchange (SPHINX) is a Commodore users group in the San Francisco area. Meetings and classes are held, a newsletter is produced, and a bulletin board is maintained. SPHINX also distributes public-domain software and equipment. Suggestions are welcome. Annual membership dues are $24. For information, send $2 for a catalog, or contact SPHINX, 267 Arlington Ave., Kensington, CA 94707, (415) 527-9286.

Compucats of Maryland

The Compucats Computer Club, sponsored by the Software Development Company of Aberdeen, Maryland, opens the monthly meetings to all those interested in computing. Although the focus is on Commodore computers, many members own other systems. Meetings are held at 7 p.m. on the second Tuesday of each month and include demonstrations. The club sponsors shows and programming contests. A monthly program disk and a monthly newsletter entitled *The Compucats Chronicle* are produced. Dues are $15 a year and provide members with access to the club-maintained library of hardware and software. For details, write to Betty Jane Schueler, Compucats Computer Club, 680 West Bel Air Ave., Aberdeen, MD 21001, or call (301) 272-4195.

Japanese Atari Club

An Atari users group, the Ryukyu Atari Motivators (RAM), welcomes new members, information, and newsletter exchanges. RAM is an affiliate of the Okinawa Computer Club, which serves users of many kinds of computers. For details, write W. Martin Justice, PSC#2, Box 11165, APO SF, CA 96367.

See BASIC News

CBNews, the monthly newsletter of the CBASIC Compiler Users Group (CBUG), is produced by Software Magic for the benefit of CB80 users. It covers corporate news, letters, new products such as conversion tools, and bugs. Call the CB80 hotline, (213) 765-3957, with problems or questions. A 12-issue subscription is $12. Contact *CBNews*, Software Magic, 11669 Valerio St. #213, North Hollywood, CA 91605, (213) 765-3957.

National Capital Group for Apple

Washington Apple Pi meets at 10 a.m. on the fourth Saturday of each month in Bethesda, Maryland, on the campus of the National Naval Medical Center. Meetings include speakers and cover such topics as databases and the uses of personal computers by disabled persons. A sign interpreter and reserved seating are provided. The club maintains a hotline serving 4000 members and produces a monthly publication. For further information, contact Washington Apple Pi, Suite 201, 8227 Woodmont Ave., Bethesda, MD 20814, (301) 654-8060.

Massachusetts CP/M Users Meet

The Central Mass CP/M Users Group welcomes CP/M and VT-180 users to meetings held at 2 p.m. on the first Sunday of every month in Shrewsbury, Massachusetts. The intention of the meetings is to distribute information and there are no dues. For further details, contact Brother Jim Smith, Saint John's High School, 378 Main St., Shrewsbury, MA 01545, or call (617) 845-1878.

Applications for the Blind

Raised Dot Computing Newsletter is free to owners of Braille-edit, a software program that works in print, braille, and voice. The monthly newsletter will cover the applications of small computers for the blind and for transcribers, low-cost braille devices and translation, and voice synthesis. Subscriptions are available in the two forms of print or audio; 12 print issues cost $12 and 12 cassettes cost $20. A sample print issue is free; back issues are $2 each. For information, contact Raised Dot Computing, 310 South 7th St., Lewisburg, PA 17837, (717) 523-6739.

CP/M Grows in Napa Valley

The Napa Valley CP/M Users Group (NVCPMUG) meets at 7:30 p.m. on the second Wednesday of each month at the Napa Valley College Campus and welcomes anyone interested. Meetings are free and there are no membership dues. Topics include system languages and hardware applications related to CP/M. The newsletter is on line 24 hours a day on the club's remote CP/M bulletin-board system (RCPM). To access the Napa Valley RBBS/RCPM, call (707) 257-6502, or mail a self-addressed, stamped envelope to NVCPMUG, POB 4096, Napa, CA 94558.

Cooking With Gas

The Sacramento Area Users of Televideo Equipment (SAUTE') meets twice a month to listen to lectures prepared by one of the members on applications relevant to programmers and systems analysts who use Televideo TS802 and TS803 systems. After each meeting is an open discussion; printed minutes are distributed. Exchanges of information or out-of-town members who would benefit from the communications are welcome. Dues are $12 a year. For details, contact Ron Odom, SAUTE', 8200 Longden Circle, Citrus Heights, CA 95610.

Silicon Valley Hosts dBASE II Users

The dBASE II User Group/Silicon Valley meets at 7 p.m. on the first Wednesday of each month in Sunnyvale, California. It is designed for all levels of users of Ashton-Tate's dBASE II. There are no dues. For details, contact Melissa Gray, dBASE II User Group/Silicon Valley, POB 190, Mountain View, CA 94042-0190. ■

If you would like BYTE readers to know about your club or newsletter send the details accompanied by no more than one newsletter to Clubs and Newsletters, BYTE Publications, POB 372, Hancock, NH 03449. Overseas groups are encouraged to participate. Please allow at least three months for your announcement to appear.

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Capital Strategy for Investors, an investment-planning program. By performing mathematical calculations, this program not only lets you decide what to invest in, but how much to invest. The computer will provide information for optimal capital growth without financial strain, show the effects of the growth rate, and test the results of varied investment decisions. For II Plus, IIe, and III; floppy disk, $69. Ventura Data Systems, 1061 Sage View, Chula Vista, CA 92010.

Family Medical Advisor, a medical-diagnostics program. This program is designed to analyze health symptoms and identify probable causes of medical conditions, including drug abuse and poisoning. Using almost 10,000 combinations of symptoms, the program helps to diagnose common ailments, obscure diseases, or childhood illnesses. You reply with yes and no answers to a series of questions. For informational purposes only. For the II; floppy disk, $37.50. Navic Corp., Box 14727, North Palm Beach, FL 33408.

Gene Machine, an educational program for use by high school biology students. This program explores the basic ideas concerning the structure and function of the two nucleic acids, DNA and RNA. Also useful for chemistry courses that include aspects of the chemical basis of heredity. For II, II Plus, and IIe; floppy disk, $65. HRM Software, 175 Tompkins Ave., Pleasantville, NY 10570.

The Graphics Department, an integrated graphics system for use in business presentations. This program combines the graphics functions of plotting, chart generation, lettering, a graphics editor, and a slide projector to quickly create and enhance your own business presentations. For II, IIe, and III; floppy disks, $124.95. Sensible Software Inc., 6619 Perham Dr., West Bloomfield, MI 48033.

Health Awareness Games, five interactive software programs suitable for school or home uses. A variety of age groups can increase their health awareness with programs entitled Coronary Risk, Why Do You Smoke?, Exercise Weight, Life Expectancy, and Life Style. For II, II Plus, and IIe; floppy disk, $99. HRM Software (see address above).

Heredity Dog, an interactive, educational genetic simulation. High school students combine genetic differences in dogs as an introductory study of basic genetics. The computer shows potential outcomes in litters of pups. For II, II Plus, and IIe; floppy disk, $49. HRM Software (see address above).

Homeword, a personal word-processing program that leads you through each step. You can write letters, school assignments, shopping lists, and memos. Text combined with pictures (icons) show you text commands and your formatted page. For II, II Plus, and IIe; cassette and floppy disk, $49.95. Sierra On-Line, Sierra On-Line Building, Coarsegold, CA 93614.

Mad Rat, an arcade-type game. Three mice are trapped in a department store. You must get them to eat the cheese while also keeping them away from the cat and the holes under the escalators. If the cheese drops through the escalator holes, it turns into more cats. Various skill levels. For II, II Plus, and IIe; floppy disk, $24.95. Phoenix Software Inc., 64 Lake Zurich Dr., Lake Zurich, IL 60047.

Mastering the College Board Achievement Tests: English Composition, a comprehensive program for individuals preparing to take College Boards. This self-paced program has more than 1000 problems to give you practice in rewriting sentences, phrasing, identification of grammatical errors, and pointers on sentence structure. It provides scores and error analysis for further study. For II Plus and IIe; floppy disks, $175. CBS Software, 1 Fawcett Place, Greenwich, CT 06836.

Murder by the Dozen, a whodunit-simulation series. This is a game containing 12 murder mysteries and their case histories. You are the top detective and must solve each case within a limited amount of time using clues and a map of the city. Up to four people can play individually or as a team. For II Plus and IIe; floppy disk, $34.95. CBS Software (see address above).

Pconvert, a data-transferral system. Data, text, and code files can be transferred between DOS 3.3 and Apple Pascal format disks. You can use BASIC data or text files with Pascal programs; Pascal text or data files with BASIC programs; and code files from the Pascal 6502 assembler as DOS binary files. For II, II Plus, and IIe; floppy disk, $34.95. DESC Software, POB 7212, Stanford, CA 94305.

Picture Writer, an artistic educational program. Children ages 4 through 12 can easily draw lines, shapes, and pictures. A tutorial teaches the child to draw original pictures using the keyboard, use the artwork on disk, alter or store pictures, and add color. This teaches spatial and color relationships and the basics of early programming skills. For II, II Plus, IIe, and III; floppy disk, $39.95. Scarborough Systems Inc., 25 North Broadway, Tarrytown, NY 10591.

Project for an Energy Enriched Curriculum (PEEC), a collection of six independent, integrated programs on energy-conservation issues. Technical Education Research Centers (TERC) and the National Science Teachers Association (NSTA) aided in the development of these six programs that include Electric Bill, Energy Conversions, Home Energy Savings, Personal Energy Inventory, Power Grid, and Temperature Grapher. For II, II Plus, and IIe; floppy disk, $225 for all six programs; also available individually. HRM Software (see address above).

Songwriter, a music-composing system for ages four through adult. Compose or learn theory with music and a metronome already on disk. Manipulate tempo or scale by touching a key; print out your composition; or hear it on a computer or stereo. Includes a cable that connects the stereo to the computer. For II, II Plus, IIe, and III; floppy disk, $39.95. Scarborough Systems Inc. (see address above).

Super Quiz II, a multiple-choice test-generation system. This educational tool enables teachers and ad-

ministrators to create a test bank of up to 10,000 questions; add, edit, or replace questions; print copies of exams; and choose from a dozen other tasks. For II, II Plus, and IIe; floppy disk, $49.95. Sterling Swift Publishing Co., 7901 South IH-35, Austin, TX 78744.

Termexec, a comprehensive communications package. You can log in via modem to a remote host computer, electronic bulletin-board system, or an information, news, or stock-market service. Features include expanded character set, long-file handling, scrolling, macro commands, exec files, full-screen editor, and more. A hotline is available for technical support. For II Plus and IIe; floppy disk, $79.95. Exec Software Inc., 201 Waltham St., Lexington, MA 02173.

Atari

Cosmic Tunnels, an arcade-type game. Save your planet Sirref from energy starvation the Jebs have imposed by destroying their space mines and missile launchers. Then retrieve as many glowing energy bars from four asteroids as you can while avoiding dynobots and quicksand. For 800 and 1200; floppy disk, $34.95. Datamost Inc., 8943 Fullbright Ave., Chatsworth, CA 91311-2750.

FDOS, a disk operating system for FORTH users. In addition to performing normal DOS 2.0S file manipulations, this program also converts DOS files to FDOS files that are saved on your FORTH disk. You can create data files with existing BASIC programs operating under DOS 2.0S, and then convert them for use in a FORTH program. For 400/800 and 1200; floppy disk, $39.95. Superware, 2028 Kingshouse Rd., Silver Spring, MD 20904.

Hellcat Ace, a flying-combat simulation. The three-dimensional scene is in the Pacific during WWII. You confront 14 scenes in time ranging from 1940 to defending the fleet from Kamikaze attacks during the invasion of Iwo Jima in March 1945. Become an ace by maneuvering your aircraft through aileron rolls, loops, split Ss, and Immelmann turns. For 400/800; floppy disk, $29.95. Microprose Software, 10616 Beaver Dam Rd., Hunt Valley, MD 21030.

Major League Hockey, a hockey-simulation game. Use your maneuvering ability to score goals and beat the other team. Features include a scrolling display of the rink and a game timer. Because the ice rink is triple the screen size, your view of the rink changes according to where the puck is. For 400/800 and 1200; cartridge, $44.95. Thorn Emi Home Video, 1370 Avenue of the Americas, New York, NY 10019.

Monster Smash, an arcade-type game. You are the master of the local graveyard. The monsters who have moved in have destroyed the peace and quiet and are trying to escape through the gates. You must smash as many monsters as possible but let all the visitors and children pass through the gates unharmed. For 400/800 and 1200; floppy disk, $29.95. Datamost Inc. (see address above.

Mountain King, an arcade-type game. Armed only with a flashlight and a thirst for adventure, you delve into the heart of a secret mountain and try to capture the crown. Carry it safely to the top of the mountain before your time expires and you will become Mountain King; if not, you will be destroyed. Requires a joystick. For 400/800; cartridge, $25. CBS Software, 1 Fawcett Place, Greenwich, CT 06836.

Party Mix, a collection of five arcade-type games. In Bop a Buggy, you drive a two-wheeled buggy through various screens to cross the finish line. In Tug of War, your team tries to pull the opposing team across the line. In Wizard's Keep, you control a wizard who releases his fireball to hit chickens or ships. In Down on the Line, workers must move packages around on colorful conveyor belts. In Handcar, you race on railroad tracks across the desert. For the 2600; cartridge, $9.95. Epyx/Automated Simulations, 1043 Kiel Court, Sunnyvale, CA 94089.

Pooyan, a high-resolution arcade-type game. Battle a pack of vicious wolves to protect your helpless piglets. You shoot arrows at wolves that float in the air by holding onto balloons. For 400/800 and 1200; floppy disk, $29.95. Datasoft, 9421 Winnetka Ave., Chatsworth, CA 91311.

Scroll It, a machine-language program. You can implement variable-speed fine scrolling in a BASIC program. The fine scrolling can be continuous horizontal, vertical, or diagonal; the ANTIC character mode can be changed; and the screen can be coarse scrolled to any *x,y* location. For 400/800; floppy disk, $19.95. Superware (see address above).

Solar Fox, an arcade-type space-adventure game for one or two players. As Earth runs out of energy, you must navigate your starship through a complex matrix of solar cells guarded by fireball-shooting Sentinels. The faster your speed, the greater your reward. See if you can unlock the secret of the Solar Fox. For the 2600; cartridge, $25. CBS Electronics, 41 Madison Ave., New York, NY 10010.

Space Knights, a group of simulated science-fiction adventure games. As you follow Jake and Lisa through challenging encounters, you try to land your rocket on the surface of an alien planet or race through the Corridor of Time. Learn vector-trigonometry fundamentals in Navigate. For 400/800; floppy disk and book, $24.95. Reston Publishing Co. Inc., 11480 Sunset Hills Rd., Reston, VA 22090.

CP/M

Datacure, an error-detecting and backup/restore utility program for CP/M version 2.2 operating systems. Using proprietary error-detection and correction techniques, you can reconstruct the original contents of disk sectors that have gone bad. Rebuild the original file and regenerate all the information for a complete track or for sectors damaged by a multitrack scratch. Floppy disk, $99. Colorado Online Systems Inc., 40 Balfour Lane, Ramsey, NJ 07446.

FORTRAN Relabel, a label-renumbering program. All the numeric labels in FORTRAN programs containing statements and all labeled line references can be renumbered using this program. Subroutines, function subprograms, and Microsoft EDIT80 line numbers are processed automatically. You specify ASCII code and the numeric value of desired

label and increment. Floppy disk, $29.95. Cleydale Engineering, POB 784, Dahlgren, VA 22448.

Magicbind, a word-processing program. Upgrade your word-processing equipment with automatic numbering of chapters, paragraphs, and articles; automatic printing of personalized letters for mass mailing; print-time selection of records; automatic verification of data-file accuracy; flexible page heading and footing; and other capabilities. Floppy disk, $250. Computer Editype Systems, 509 Cathedral Parkway 10A, New York, NY 10025.

Printman, a print-spooler system. An alternative to the standard DESPOOL and SPOOL programs. Minicomputer capabilities such as add, change, delete, list, and others give you increased system use. Perform more functions on files with special features and enter any number of items to the list. Floppy disk, $195. Data Base Administrators Inc., W305 S4553 Brookhill Rd., Waukesha, WI 53186.

The Word Machine, a word-processing/text-editing program. Transform your computer into an automatic typewriter letting you create, edit, store, and print letters, forms, manuscripts, and personalized form letters. Detailed help instructions are included. Floppy disk, $37. GB Associates, POB 3322, Granada Hills, CA 91344.

Commodore

The Complete Personal Accountant, five personal financial programs. This package transforms your computer into a financial manager with a checkbook-maintenance program, a detailed summary budget, an appointments and payments calendar, a "what if" spreadsheet, and a tax-handling format. For the 64; floppy disk, $79.95. Programmer's Institute, POB 3470, Chapel Hill, NC 27514.

Easy Finance I—V, five financial-calculation programs that include a loan-analysis program, an investments-analysis program, an advanced investments-analysis package, a business-management package, and a statistics and forecasting package. For the 64; floppy disks, I: $39.95, II—V: $24.95. Commodore Business Machines Inc., 1200 Wilson Dr., West Chester, PA 19380.

Easy Script, a word-processing program. You can create, store, modify, and print text. A training section introduces you to ten sections that include exercises, applications, and format examples. A reference section shows you how to use the facilities, including mail-merge. For the 64; floppy disk, $50. Commodore Business Machines Inc. (see address above).

Final Orbit, an arcade-type game. You must stop the Maladroid fighters who are raiding the Earth. You lose energy each time Earth or your fighter gets hit. Try to regain energy by destroying a Maladroid base. Bumper Bash included for free. For the VIC-20; cartridge, $39.95. Sirius Software Inc., 10364 Rockingham Dr., Sacramento, CA 95827.

Spitfire Ace, an air-combat simulation game. Fly your WWII fighter in loops, rolls, and split-S maneuvers to win in 14 scenarios. If you can complete five missions that include the Battle of Britain and the challenge of the first jet fighter, you become an ace. For the 64; floppy disk, $29.95. Microprose Software, 10616 Beaver Dam Rd., Hunt Valley, MD 21030.

Squish 'Em, an arcade-type game. As you climb to the top of a 48-story building to collect a suitcase of money, try to avoid being knocked off the building by a variety of Creepy Creatures or falling objects. For the VIC-20; cassette, $19.95. Sirius Software Inc. (see address above).

3-D Othello, a three-dimensional board-game simulation of Othello in machine-language programming. Two players can compete in four skill levels with colorful graphics and sound effects for younger players. Helps to develop spatial perspective and strategic skills. Requires a joystick. For the VIC-20; cassette, $15. Ojai Software, POB 1860, Ojai, CA 93023.

IBM Personal Computer

Aura, an integrated information-management system containing word-processing, electronic-spreadsheet, business-graphics, and communications programs with an optional micro-mainframe communications link. You can create business reports of customers with outstanding balances, weed inactive accounts from mailing lists, track sales by product and region, and create reorder lists of low inventory. Floppy disks, $495; with communications-link capacity, $995. Softrend, 87 Indian Rock Rd., Windham, NH 03087.

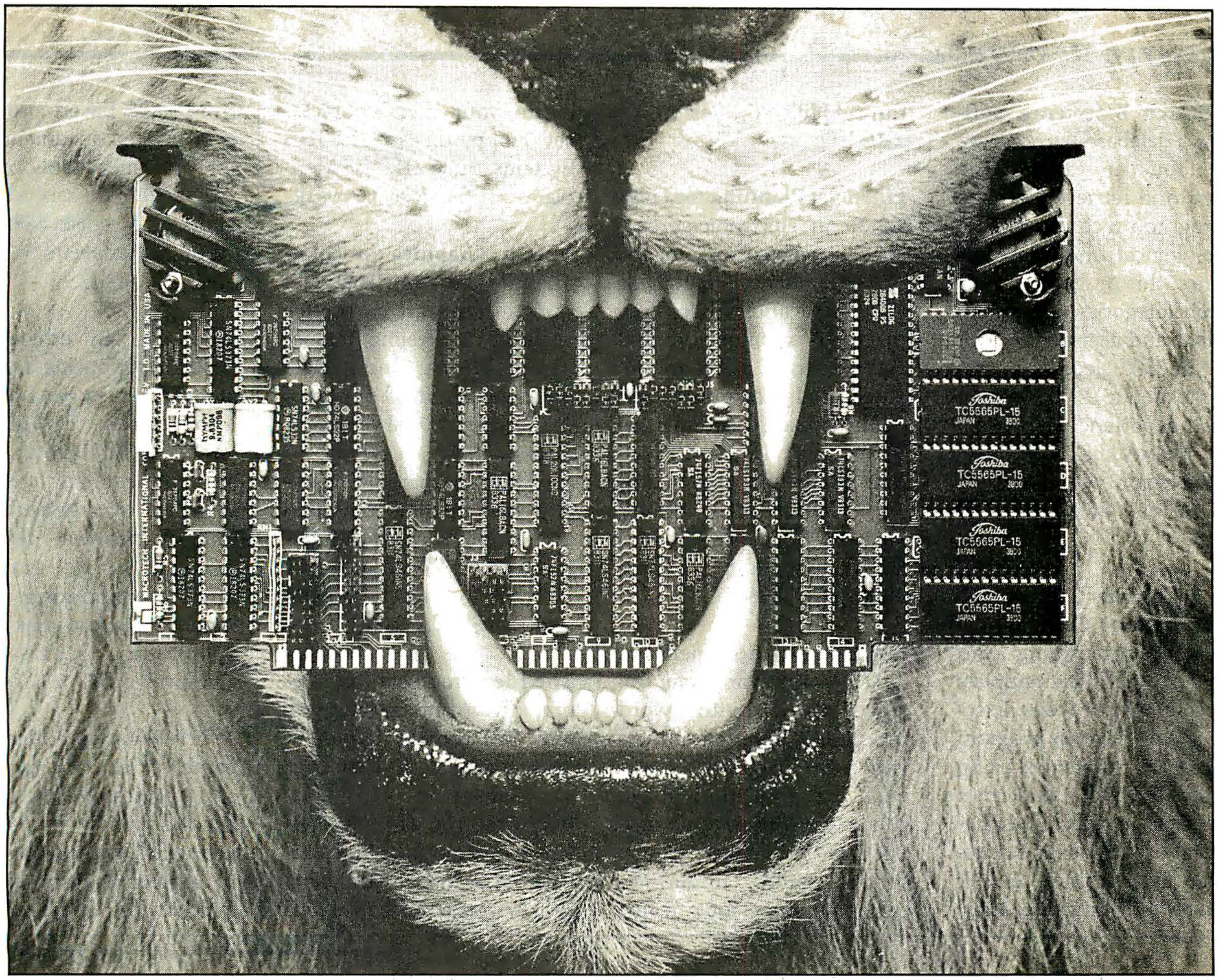
BASLIN, a BASIC line number/page program. This utility is designed to let BASIC use programs that were previously created as a program library. You can combine programs, renumber the listing, and create a new, enhanced program. Floppy disk, $35. Orion Co., 524 North 2nd St., Weatherford, OK 73096.

Burgertime, an arcade-type game. Your chef is in a maze surrounded by pickles, hot dogs, and eggs that are trying to get him. If they catch him, his fast-food career is over. Try to sprinkle pepper on a pickle and dodge down a ladder. Floppy disk, $25. Mattel Electronics, 5900 Wilshire Blvd., Los Angeles, CA 90036.

Chartmaster, a commodity- and stock-charting program. You can examine, analyze, display, and print a variety of price charts. You can also generate high, low, close bar, and moving averages. The database can be updated by retrieving stock or commodity price information via data communications. Floppy disks, $275. Professional Farm Software, 219 Parkade, Cedar Falls, IA 50613.

Conquest, a prehistoric-simulation game. As King of the Falcons, you use your strength and endurance against pterodactyl warriors. You must swoop down to destroy them while encountering hurricanes, tornados, and dragons trying to deter you. Floppy disk, $39.95. Windmill Software Inc., 2209 Leominster Dr., POB 1008, Burlington, Ontario L7P 3W8, Canada.

CP+, a collection of training and productivity programs for your computer. It is a user-friendly interface between you and the command interface of the operating system and provides extended utility features. Designed for nontechnical users. Floppy disk, $79.95. Taurus Software Corp., Suite 170, 3155 Kearney, Fremont, CA 94538.



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EMSearch Bioscience Software, a database-retrieval system. You can store, cross-index, and retrieve electron-micrograph records. For use in biological and materials science, this program uses 14 search categories (specimen, fixative, and user-defined) for 4200 to 8500 electron micrographs on one disk. No computer experience is necessary. Floppy disk, $99. New Leaf Enterprises Inc., 1901 C Waters Edge, Ft. Collins, CO 80526.

The Executive's Guide to the IBM Personal Computer, a BASIC programming and Visicalc spreadsheet template for business purposes. Executives can learn to program chapter by chapter by using payroll, inventory, and other business examples. Mathematical experience is not required. Floppy disks, $49.95. Reston Publishing Co., 11480 Sunset Hills Rd., Reston, VA 22090.

Financial Planning for Lotus 1-2-3, an electronic-spreadsheet template program. You can calculate 16 financial planning and forecasting problems contained on disk. Each program, called a worksheet, is a complete and ready-to-use program that solves several related financial problems with Lotus 1-2-3. Floppy disk, $89.95. Howard W. Sams & Co. Inc., 4300 West 62nd St., Indianapolis, IN 46268.

Fontastic, a document-enhancing printer program. Designed to work with a word processor, this program lets you print diagrams, drawings, and foreign language characters with 20 fonts supporting sub- and superscripts, italics, underline, bold, and more. You can also create your own character set. Floppy disks, $125. IHS Systems, Suite 211, 4718 Meridian Ave., San Jose, CA 95118.

4-Point Graphics, a color-graphics program that features a four-part cursor for versatility in creating, manipulating, storing, and retrieving images from all or part of the screen. Dual memory buffers allow access to images for comparison, overlays, and creation of animation. Floppy disk, $195. International Microcomputer Software Inc., 633 Fifth Ave., San Rafael, CA 94901.

The Idea Processor, an integrated word-processing system and textual data-management system that run simultaneously. This program lets you save spreadsheets and graphics in a database, cross-index them using 10 keywords, use graphics from DOS-based programs in its printed documents, and put on a slide-show presentation with a graphics program. Floppy disk, $295. Idea Ware, 225 Lafayette St., New York, NY 10012.

Knoware, an educational program for business professionals that teaches business applications. By playing games, you learn about spreadsheet applications, database management, text editing, financial decision-making, simple graphics, and programming techniques. Floppy disk, $95. Knoware Inc., 301 Vassar St., Cambridge, MA 02139.

Match Wits, an educational game for the whole family. In six categories (words, sports, famous people, multiplication, cities, and animals), you try to match pairs to uncover a hidden picture puzzle. You

can also create and program your own categories. Floppy disk, $29.95. CBS Software, 1 Fawcett Place, Greenwich, CT 06836.

Night Stalker, an arcade-type game. Your man is trapped in a maze with robots, spiders, and bats trying to track him down. Destroy them with your gun before they get him. Floppy disk, $24. Mattel Electronics (see address above).

PC Write, a word-processor and text-editor program. This program helps you write and format any text. Features include insert, replace, delete, wordwrap, search, move and copy blocks, a split-screen mode, and functions for more advanced users. Floppy disk and manual, $35. User registration fee, $75. Quicksoft, 219 First North #224, Seattle, WA 98109.

Pits & Stones, an artificial-intelligence strategy game for all ages. Try to collect the most stones in your home pit by taking turns distributing them. Plan each move ahead while anticipating your opponent's strategies. Floppy disk, $36.95. Orion Software, POB 2488, Auburn, AL 36831.

Realpac, a collection of real estate analyses programs. Features include files that let you calculate fixed rate, fixed principal reduction, graduated payment and equity, renegotiable/variable rate amortization schedules, internal rate of return calculator, and other programs related to real estate purchasing and sales. Floppy disks, $275. Creative Business Computer Systems Inc., 6731 Red Rd., Coral Gables, FL 33143.

Rogue, a fantasy-adventure game. You are on a quest for the amulet of Yendor in the Dungeons of Doom. Discover magical objects, food, and weapons, but beware of the monsters lurking in the darkness. Floppy disk, $44.95. Artificial Intelligence Design Systems, POB 3685, Santa Clara, CA 95055.

SR-LIB, a library-manager program. You can create and modify library files that are compatible with the PC-DOS linker. Add object files, delete and replace modules in a library, and list the names of the modules in a library. Floppy disk, $29.95. Software Research, POB 10004, Austin, TX 78766.

Scientific Mathematical Function Library, a mathematical-applications system. This Microsoft package is for C programmers in engineering and graphics who need more mathematical sophistication than C provides. Features include 20 functions, fatal errors, warning errors, and a math library of three files. Floppy disk, $45. Soft C, 14350 Southwest Derby St., Beaverton, OR 97005.

Small Fortune Auto-Ledger, a general-ledger program. Handle your bookkeeping by structuring your accounts and reports. Designed for business-accounting needs, features include transaction entries, suggested accounts, setting up reports, testing templates, and updating records. Floppy disks, $250. Emerald Software Inc., 2416 Warren Ave. N, Seattle, WA 98109.

Tiào Ch'i, a Chinese-checkers simulation game. Played on a six-pointed star, two to six players take turns consecutively moving men from their star point to the opposite star point. Whoever makes it in the least number of moves is the winner. Floppy disk, $24.95. Microclassics, 315

West Grand Ave., El Segundo, CA 90245.

Osborne 1

Cost Estimating With Risk Analysis (CEWRA), a spreadsheet-template business program designed to let you estimate project costs using fundamental risk-analysis techniques. It includes three types of estimates: constant, uniform, and triangular for project-cost elements such as labor, materials, and capital. For use with Supercalc. Floppy disk, $39. CPG Inc., POB 1057, Chester, VA 23831.

Multi-Factor Productivity Measurement Model for Small Business (MFPMM-SB), a spreadsheet-template small-business program. Enter the price and quantity data for input and output factors and you receive calculated desired productivity indexes, ratios, and their impact on profits. For use with Supercalc. Floppy disk, $79. CPG Inc. (see address above).

TRS-80

Accounts Receivable, an accounting program that monitors sales and incoming funds. Features include a balance-forward system, a capacity of up to 2000 transactions per month with 150 customers on file, optional late-charge processing, mailing labels, and printing of general-ledger reports. For the Model 4; floppy disks, $199.95. Radio Shack, 300 One Tandy Center, Ft. Worth, TX 76102.

COBOL for the TRS-80, Volume One, an instructional package designed to teach the fundamentals of COBOL programming to secondary and college-level students. Each chapter of the manual includes an overview, objectives, hands-on experience, flowcharts and diagrams where applicable, programs, discussion, a summary, and review. For Models II, 12, and 16; floppy disk, $49.95. Radio Shack (see address above).

Corplan, a business-simulation program. This educational package is designed to supplement business instruction at the college or advanced secondary levels by simulating corporate operations. This program puts a player or a team in control of a theoretical corporation, planning overall business policy and applying the decisions needed for success. No computer experience is needed. For Models III and 4; floppy disk, $49.95. Radio Shack (see address above).

Diskdisk, a hard-disk file-allocation program. You can turn your hard-disk drive into a logical series of floppy-disk drives. Create files on a disk that appear to the system to be other disk drives. All system functions are available as if these files were actual drives. Mirror-image backups function normally. For Models I and III (version 5.1) and Model 4 (version 6.0); floppy disks, $99. Logical Systems Inc., 8970 North 55th St., POB 23956, Milwaukee, WI 53223.

Examiner, a BASIC program for teachers to administer tests to students at a computer. Students find out immediately if their answers are right or wrong. Teachers can display student grade lists and answers, and determine the selected test items that need review by the frequency of errors. For Models III and 4; floppy disk, $69.95. Microsoftware Services, POB 776, Harrisonburg, VA 22801.

Guardian, an arcade-type game. Protect ten energy modules that enemy ships are trying to steal from your planet's force field. Catch, but do not destroy, the enemy with a stolen module or else the energy will be lost and the enemy will transform to a higher energy state. For the Color Computer; floppy disk, $29.95; cassette, $27.95. Quasar Animations, 1520 Pacific Beach Dr., San Diego, CA 92109.

Investment Analysis, a portable three-program package. Fixed Income Security Evaluator calculates data useful for buying or selling fixed-income securities. Commission Calculator calculates commission charges for stock and option transactions. Option Strategy Evaluator calculates the results of option transactions involving vari-

ous combinations of put and call purchases and sales. For the Model 100; cassette, $69.95. Radio Shack (see address above).

LS-HOST/Term, a telecommunications package. This set of seven programs lets the Model 4 emulate an ADDS 25 terminal with video effects. The computer can also be remotely controlled by another computer or terminal. Package includes a binary-to-ASCII conversion utility and a file-transfer program using Christiansen protocol. For the Model 4; floppy disk, $199. Logical Systems Inc. (see address above).

MLIB, a program that aids in the construction of Microsoft-compatible relocatable object-file libraries. Commands let you add, replace, copy, or delete modules from existing libraries or you can create new libraries from individual modules. For Models I and III; floppy disk, $50. Misosys, POB 4848, Alexandria, VA 22303-0848.

Real Estate Investment Analysis, five financial-planning programs. Mortgage Analysis calculates percentages of loans, mortgages, amortization, and more. Mortgage Equity Analysis calculates values, resale prices, ratios, and yields. Present Worth Analysis calculates the present value and worth of steady and uneven income. Utility Routine Analysis calculates interest, expenses, budgets, capitalization rate, and more. Statistical Analysis performs tests using decision-tree and time-trend analysis to forecast net-operating income. For the Model III; floppy disk, $99.95. Radio Shack (see address above).

The Traveling Appointment Manager, a portable appointment-reminder program. Keep track of personal and professional appointments. Enter dates up until the turn of the century. Old appointments are erased unless you reschedule them. You can also list things-to-do and print your calendar. For the Model 100; cassette, $59.95. Traveling Software Inc., 11050 Fifth Ave. NE, Seattle, WA 98125.

The Traveling Time Manager, a portable time-keeping program. You can keep track of billable and nonbillable work hours. Other applications include keeping track of expenses, recording and listing student grades, managing equipment and machinery usage, tracking a runner's miles, and averaging time per mile. For the Model 100; cassette, $59.95. Traveling Software Inc. (see address above).

TRS-80 Wordstar, an adapted version of the word-processing program by Micropro. Features include automatic line wrap, margin set, and various other text adjustments. On-screen help and prompts let you design and lay out your pages. The documentation describes the differences between the two versions. Includes sinal-LDOS, an enhanced operating system. For the Model III; floppy disk, $395. Logical Systems Inc. (see address above).

Other Computers

Picture Perfect, a business-graphics system. With this program you can transform your data into pies and exploded pies, vertical and horizontal bar charts, or line charts. Features include numerous bar and pie shading patterns. For the Hewlett-Packard HP 150; floppy disk, $295. Computer Support Corp., 4215 Beltwood Parkway, Dallas, TX 75234.

Stock Control, a stock-control system. You can keep 500 items per file with a two-second access time. Features include an audit trail, item/supplier search facilities, reorder levels, nine menu options, and unlimited entries. For the Timex/Sinclair 2000 (Spectrum); cassette, £14.95. Kemp Limited, 43 Muswell Hill, London N10 3PN, England.■

This is a list of software packages that have been received by BYTE Publications during the past month. The list is correct to the best of our knowledge, but it is not meant to be a full description of the product or the forms in which the product is available. In particular, some packages may be sold for several machines or in both cassette and floppy-disk format; the product listed here is the version received by BYTE Publications.

This is an all-inclusive list that makes no comment on the quality or usefulness of the software listed. We regret that we cannot review every software package we receive. Instead, this list is meant to be a monthly acknowledgment of these packages and the companies that sent them. All software received is considered to be on loan to BYTE and is returned to the manufacturer after a set period of time. Companies sending software packages should be sure to include the list price of the packages and (where appropriate) the alternate forms in which they are available.

Books Received

Ada, An Advanced Introduction, Narain Gehani. Englewood Cliffs, NJ: Prentice-Hall, 1983; 700 pages, 18 by 24.3 cm, hardcover, ISBN 0-13-003997-7, $28.95.

Advanced BASIC, Roy A. Boggs. Reston, VA: Reston Publishing Co., 1983; 208 pages, 15.3 by 22.8 cm, softcover, ISBN 0-8359-0161-0, $16.95.

Affordable Word Processing, Richard A. McGrath. Englewood Cliffs, NJ: Prentice-Hall, 1983; 160 pages, 15.3 by 22.8 cm, softcover, ISBN 0-13-018259-1, $10.95.

Applied Numerical Methods for the Microcomputer, Terry E. Shoup. Englewood Cliffs, NJ: Prentice-Hall, 1984; 272 pages, 15.8 by 23.8 cm, hardcover, ISBN 0-13-041418-2, $25.95.

Basic Beginnings, Susan Drake Lipscomb and Margaret Ann Zuanich. New York: Avon/Camelot Books, 1983; 96 pages, 13 by 19 cm, softcover, ISBN 0-380-83774-9, $2.25.

BASIC-80 and CP/M, Jack Jay Purdum. New York: Macmillan Publishing Co., 1983; 240 pages, 17.5 by 25.5 cm, softcover, ISBN 0-02-397020-0, $16.95.

Basic & Pascal In Parallel, S. J. Wainwright. London, England: Bernard Babani Ltd., 1983; 64 pages, 11 by 18 cm, softcover, ISBN 0-85934-101-1, £1.50.

BASIC-PLUS for Business, Wilson T. Price. New York: Holt, Rinehart and Winston, 1983; 350 pages, 23.5 by 17.5 cm, softcover, ISBN 0-03-061768-5, $17.95.

Basic Programs for Production and Operations Management, Pricha Pantumsinchai, M. Zia Hassan, and Ishwar D. Gupta. Englewood Cliffs, NJ: Prentice-Hall, 1983; 448 pages, 15 by 22.5 cm, softcover, ISBN 0-13-066266-6, $14.95.

Battlestar BASIC for the TRS-80, David H. Dasenbrock. Indianapolis, IN: Howard W. Sams & Co., 1983; 104 pages, 13.5 by 21.5 cm, softcover, ISBN 0-672-22006-7, $12.95.

CP/M Bible, Mitchell Waite and John Angermeyer. Indianapolis, IN: Howard W. Sams & Co., 1983; 432 pages, 18 by 23 cm, softcover, ISBN 0-672-22015-6, $19.95.

CP/M and the Personal Computer, Thomas A. Dwyer and Margot Critchfield. Reading, MA: Addison-Wesley, 1983; 512 pages, 21.8 by 28 cm, softcover, ISBN 0-201-1-355-9, $19.95.

Churches, Charities & Computers, G. Walter Coles. Huntington Beach, CA: Coles Associates, 1983; 208 pages, 13.5 by 21 cm, softcover, ISBN-none, $15.

Commodore Software Encyclopedia, 3rd ed. Commodore Business Machines Inc., West Chester, PA: Commodore Electronics Ltd., 1983; 896 pages, 21.5 by 28 cm, softcover, ISBN 0-672-21944-1, $19.95.

The Complete Book of Home Computers, Van Waterford. Blue Ridge Summit, PA: Tab Books, 1982; 256 pages, 13 by 20.5 cm, softcover, ISBN 0-8306-1423-0, $10.95.

Computer Assisted Investment Handbook, Albert I. A. Bookbinder, Elmont, NY: Programmed Press, 1983; 230 pages, 17.8 by 25 cm, softcover, ISBN 0-916106-03-9, $19.95.

Concepts for Distributed Systems Design, Gregor von Bochmann. New York: Springer-Verlag, 1983; 274 pages, 17 by 25 cm, hardcover, ISBN 0-387-12049-1, $19.

Conceptual Programming Using BASIC, Allen Baker and Kathy Hamrick. Englewood Cliffs, NJ: Prentice-Hall, 1984; 224 pages, 15 by 22.7 cm, softcover, ISBN 0-13-166678-9, $16.95.

A Course on Programming in FORTRAN, 2nd ed. Valerie J. Calderbank. New York: Methuen Inc., 1983; 196 pages, 15.5 by 23.5 cm, softcover, ISBN 0-412-23790-3, $9.95.

Data Management and File Processing, Mary E. S. Loomis. Englewood Cliffs, NJ: Prentice-Hall, 1983; 512 pages, 16 by 23.5 cm, hardcover, ISBN 0-13-196477-1, $29.95.

Developing Data Structured Information Systems, Michael H. Brackett. Topeka, KS: Ken Orr & Associates Inc., 1983; 206 pages, 21.5 by 28 cm, softcover, ISBN 0-9605884-1-8, $20.

Developing Microcomputer-based Business Systems, Chris Edwards. Englewood Cliffs, NJ: Prentice-Hall, 1983; 224 pages, 15 by 22.5 cm, softcover, ISBN 0-13-204545-1, $16.95.

Documenting Computer Application Systems, Derek A. Kelly. Princeton, NJ: Petrocelli Books, 1983; 186 pages, 16 by 24 cm, hardcover, ISBN 0-89433-206-6, $19.95.

Documentation Development Methodology, Techniques for Improved Communications, Sandra Pakin & Associates Inc., Englewood Cliffs, NJ: Prentice-Hall, 1982; 240 pages, 22 by 28.8 cm, hardcover, ISBN 0-13-217167-8, $35.

Dynamics of Visicalc, Barry D. Bayer and Joseph J. Sobel. Homewood, IL: Dow Jones-Irwin, 1983; 200 pages, 19 by 23.5 cm, softcover, ISBN 0-87094-391-X, $19.95.

Executive's Guide to Computer-Based Information Systems, James C. Wetherbe. Englewood Cliffs, NJ: Prentice-Hall, 1983; 192 pages, 16 by 24 cm, hardcover, ISBN 0-13-295428-1, $17.95.

Forecasting on Your Microcomputer, Daniel B. Nickell. Blue Ridge Summit, PA: Tab Books, 1983; 384 pages, 19.5 by 23.5 cm, softcover, ISBN 0-8306-0607-6, $15.50.

High-Tech Consulting, John Zarrella. Fairfield, CA: Microcomputer Applications, 1983; 176 pages, 15.3 by 23 cm, softcover, ISBN 0-935230-08-4, $18.95.

How to Program Your Atari in 6502 Machine Language, Sam D. Roberts. Holzkirchen, West Germany: Ing. W. Hofacker GmbH, 1982; 112 pages, 13 by 20.5 cm, softcover, ISBN 3-92-1682-97-5, $9.95.

IEEE Transactions on Communications, The Institute of Electrical and Electronics Engineers Inc. Englewood Cliffs, NJ: Prentice-Hall, 1983; 192 pages, 22 by 28.5 cm, hardcover, ISBN 0-13-450271-X, $30.

Inside the IBM Personal Computer, revised ed. Tenley Design. Washington, DC: Starware, 1982; 36 pages, 13.5 by 21.5 cm, softcover, ISBN-none, $14.

Introduction to Data Base Management in Business, James Bradley. New York: Holt, Rinehart and Winston, 1983; 642 pages, 18 by 24 cm, hardcover, ISBN 0-03-061693-X, $33.95.

Introduction to Information Processing, William M. Fuori and Dominick Tedesco. Englewood Cliffs, NJ: Prentice-Hall, 1983; 352 pages, 23.3 by 17.5 cm, softcover, ISBN 0-13-484634-6, $9.95.

Introduction to Numerical Computation in PASCAL, P. M. Dew and K. R. James. New York: Springer-Verlag, 1983; 304 pages, 15.5 by 23.5 cm, softcover, ISBN 0-387-91216-9, $16.

An Introduction to Visicalc Spreadsheeting for the TRS-80 Model III, Harry Anbarlian. New York: BYTE Books/McGraw-Hill, 1983; 448 pages, 15.8 by 23.5 cm, spiral-bound, ISBN 0-07-001597-X, $49.95. Includes 5¼-inch floppy disk.

Machine Code and Better Basic, Ian Stewart and Robin

Jones. Boston, MA: Birkhäuser, 1983; 200 pages, 16 by 24 cm, softcover, ISBN 3-7643-3115-1, $11.95.

Manager's Guide to Computers and Information Systems, Larry E. Long. Englewood Cliffs, NJ: Prentice-Hall, 1983; 416 pages, 15.5 by 23.5 cm, hardcover, ISBN 0-13-549394-3, $25.

McGraw-Hill Encyclopedia of Electronics and Computers, Sybil P. Parker, ed. New York: McGraw-Hill, 1984; 976 pages, 22.3 by 28.8 cm, hardcover, ISBN 0-07-045487-6, $59.50.

Micro Cookbook, Fundamentals, vol 1. Don Lancaster. Indianapolis, IN: Howard W. Sams & Co., 1982; 384 pages, 13.5 by 21.5, softcover, ISBN 0-672-21828-3, $15.95.

Micro Cookbook, Machine Language Programming, vol. 2. Don Lancaster. Indianapolis, IN: Howard W. Sams & Co., 1983; 13.5 by 21.5 cm, softcover, ISBN 0-672-21829-1, $15.95.

Micros for Managers, Joseph R. Little, Philip E. Mackey, and Leroy J. Tuscher. Trenton, NJ: New Jersey School Boards Association, 1983; 276 pages, 21.5 by 28 cm, softcover, ISBN 0-912337-01-1, $28.

Micro Software Distributors, Richard Loftin and Jack F. Shelton, eds. Washington, DC: Software Research Co., 1983; 192 pages, 20.3 by 26.8 cm, softcover, ISBN 0-940758-26-1, $95.

Microcomputers, A Parent's Guide, Kenneth P. Goldberg and Robert D. Sherwood. New York: John Wiley & Sons, 1983; 208 pages, 15 by 23 cm, softcover, ISBN 0-471-87278-4, $8.95.

Microcomputer Companies in the UK, 1st ed. Eurolec 58. Bristol, England: David Rayner Publisher, 1983; 370 pages, 21 by 30 cm, softcover, ISBN 0-900614-58-7, $50.

Microcomputer Experimentation with the Synertek SYM-1, Lance A. Leventhal. Englewood Cliffs, NJ: Prentice-Hall, 1983; 512 pages, 17.5 by 23.5 cm, softcover, ISBN 0-13-580910-X, $19.95.

Needed: Professional Management in Data Processing, John J. Callahan. Englewood Cliffs, NJ: Prentice-Hall, 1983; 224 pages, 15.5 by 23.5 cm, hardcover, ISBN 0-13-610956-X, $25.

New Technology Coloring Book, Rita Aero and Howard Rheingold. New York: Bantam Books, 1983; 80 pages, 21.3 by 27.5 cm, softcover, ISBN 0-553-34022-0, $6.95.

Numerical Methods for Unconstrained Optimization and Nonlinear Equations, J. E. Dennis Jr. and Robert B. Schnabel. Englewood Cliffs, NJ: Prentice-Hall, 1983; 400 pages, 16 by 23.5 cm, hardcover, ISBN 0-13-627216-9, $28.95.

101 Projects for the Z80, Frank P. Tedeschi and Robert Colon. Blue Ridge Summit, PA: Tab Books, 1983; 368 pages, 19.5 by 23.5 cm, softcover, ISBN 0-8306-1491-5, $16.95.

PDP-11 Software Source Book, 1st ed. Maynard, MA: Digital Equipment Corp., 1983; 998 pages, 13.3 by 20.3 cm, softcover, free.

The Personal Computer BASIC(S) Reference Manual, Donald A. Sordillo. Englewood Cliffs, NJ: Prentice-Hall, 1983; 336 pages, 17.5 by 23.5 cm, softcover, ISBN 0-13-658047-5, $16.95.

The Personal Computer Book, Peter A. McWilliams. Los Angeles, CA: Prelude Press, 1983; 336 pages, 15.3 by 22.8 cm, softcover, ISBN 345-31106-X, $9.95.

The Personal Computer in Business Book, Peter A. McWilliams. Los Angeles, CA: Prelude Press, 1983; 288 pages, 15.3 by 22.8 cm, softcover, ISBN 345-31294-5, $9.95.

Personal Computing with the UCSD P-System, Mark Overgaard and Stan Stringfellow. Englewood Cliffs, NJ: Prentice-Hall, 1983; 464 pages, 15.5 by 23.5 cm, hardcover, ISBN 0-13-658096-3, $23.95.

Pocket Guide to FORTH, Linda Baker and Mitch Derick. Reading, MA: Addison-Wesley, 1983; 110 pages, 10 by 15.5 cm, spiral-bound, ISBN 0-201-10103-3, $7.25.

The Politics of Projects, Robert Block. New York: Yourdon Press, 1983; 152 pages, 15 by 23 cm, softcover, ISBN 0-917072-35-9, $18.50.

Planning for Future Market Events Using Data Processing Support, Jerome Svigals. New York: Macmillan Publishing Co., 1983; 202 pages, 16 by 24.5 cm, hardcover, ISBN 0-02-949740-X, $27.95.

Planning, Implementation, and Control in Product Test and Assurance, Richard H. Spencer. Englewood Cliffs, NJ: Prentice-Hall, 1983; 222 pages, 18 by 24.5 cm, hardcover, ISBN 0-13-679506-4, $27.50.

Problem Solving and Structured Programming with FORTRAN 77, Martin O. Holoien and Ali Behforooz. Monterey, CA: Brooks/Cole Publishing Co., 1983; 528 pages, 18.5 by 23.5 cm, softcover, ISBN 0-534-01275-2, $19.95.

Program Descriptions I for Hofacker Software for your Atari Computer, Winfried Hofacker. Holzkirchen, West Germany; Ing. W. Hofacker GmbH, 1982; 128 pages, 13 by 20.5 cm, softcover, ISBN-none, $4.95.

Program Design with Pseudocode, T. E. Bailey and Kris Lundgaard. Monterey, CA: Brooks/Cole Publishing Co., 1983; 224 pages, 23.5 by 18 cm, softcover, ISBN 0-534-01361-9, $10.95.

Programming with Graphics, Garry Marshall. Englewood Cliffs, NJ: Prentice-Hall, 1983; 128 pages, 15.3 by 22.9 cm, softcover, ISBN 0-13-729608-8, $12.95.

Programming Your Timex/Sinclair 1000 in Basic, Mario Eisenbacher. Englewood Cliffs, NJ: Prentice-Hall, 1983; 208 pages, 15 by 23 cm, softcover, ISBN 0-13-729863-3, $9.95.

Questions & Answers on Word Processing, Peter A. McWilliams. Los Angeles, CA: Prelude Press, 1983; 224 pages, 15.3 by 22.8 cm, softcover, ISBN 345-31295-3, $9.95.

Reference Manual for the ADA Programming Language, ANSI/MIL-STD-1815A—1983. United States Department of Defense. New York: Springer-Verlag, 1983; 340 pages, 21.5 by 28 cm, softcover, ISBN 0-387-90887-0, $13.50.

Security Dictionary, Robert A. Hofmeister and David J. Prince. Indianapolis, IN: Howard W. Sams & Co., 1983; 176 pages, 13.7 by 21.5 cm, softcover, ISBN 0-672-220-20-4, $8.95.

The Software Catalog, Spring 1983, New York: Elsevier Science Publishing Co., 1983; 808 pages, 21 by 28 cm, softcover, ISBN 0-444-00745-8, $69.

The Software Catalog, Spring 1983 (Update), New York: Elsevier Science Publishing Co., 1983; 408 pages, 21 by 28 cm, softcover, ISBN 0-444-00749-0, $15.

The Software Catalog, Fall 1983. New York: Elsevier Science Publishing Co., 1983; 1040 pages, 21 by 28 cm, softcover, ISBN 0-444-00776-8, $69.

Stimulating Simulations for the VIC, 2nd ed. C. W. Engel. Rochelle Park, NJ: Hayden Book Co., 1983; 96 pages, 15 by 23 cm, softcover, ISBN 0-8104-5173-5, $6.50.

Structured Computer Organization, 2nd ed. Andrew S. Tanenbaum. Englewood Cliffs, NJ: Prentice-Hall, 1984; 480 pages, 18.5 by 24.3 cm, hardcover, ISBN 0-13-854489-1, $29.95.

Structured Digital Design Including MSI/LSI Components and Microprocessors, Raymond M. Kline. Englewood Cliffs, NJ: Prentice-Hall, 1983; 462

pages, 18 by 24.3 cm, hardcover, ISBN 0-13-854554-5, $28.95.

Synchronous Packet Radio Using the Software Approach, vol. 1, Robert M. Richardson. Chautauqua, NY: Richcraft Engineering Ltd., 1983; 232 pages, 21.5 by 28 cm, spiral-bound, ISBN 0-940972-07-7, $22.

Telephony: Today and Tomorrow, Dimitris N. Chorafas. Englewood Cliffs, NJ: Prentice-Hall, 1984; 304 pages, 15.3 by 22.8 cm, softcover, ISBN 0-13-902700-9, $19.95.

30 Games for the Timex/Sinclair Computer, Bill L. Behrendt. Englewood Cliffs, NJ: Prentice-Hall, 1983; 96 pages, 13.5 by 20.3 cm, softcover, ISBN 0-13-918896-7, $4.95.

26 Basic Programs for Your Micro, Derrick Daines. Indianapolis, IN: Howard W. Sams & Co., 1982; 174 pages, 13.5 by 21.5 cm, softcover, ISBN 0-672-22047-4, $8.95.

Understanding Microcomputer Concepts, Jefferson C. Boyce. Englewood Cliffs, NJ: Prentice-Hall, 1984; 336 pages, 15.3 by 22.5 cm, softcover, ISBN 0-13-936956-2, $14.95.

Using Business Basic, Wilson T. Price. New York: Holt, Rinehart and Winston, 1983; 267 pages, 19 by 23.5 cm, softcover, ISBN 0-03-063176-9, $19.95.

Using 1.2.3, Geoffrey T. LeBlond and Douglas Ford Cobb. Indianapolis, IN: Que Corp., 1983; 448 pages, 18.8 by 23.5 cm, softcover, ISBN 0-88022-045-7, $14.95.

VIC Graphics, Nick Hampshire. Rochelle Park, NJ: Hayden Book Co., 1982; 192 pages, 15 by 23 cm, softcover, ISBN 0-8104-1057-5, $12.95.

VisiWord, David Myers. San Jose, CA: Visicorp, 1983; 272 pages, 18.8 by 23 cm, softcover, ISBN 912213-01-9, $18.95.

Who's Who in Microcomputing, 1983, Datapro Research Corp. New York: McGraw-Hill, 1983; 686 pages, 21.5 by 28 cm, softcover, ISBN 0-07-015405-8, $39.95.

ZX-81/Timex, Programming in BASIC and Machine Language, Holzkirchen, West Germany: Ing. W. Hofacker GmbH, 1982; 148 pages, 13 by 20.5 cm, softcover, ISBN 3-921682-98-3, $9.95.■

This is a list of books received at BYTE Publications during this past month. Although the list is not meant to be exhaustive, its purpose is to acquaint BYTE readers with recently published titles in computer science and related fields. We regret that we cannot review or comment on all the books we receive; instead, this list is meant to be a monthly acknowledgment of these books and the publishers who sent them.

BYTE's Bits

Color Computer BBS On-Line

A computerized BBS (bulletin-board system) for users of the Radio Shack TRS-80 Color Computer is up and running 24 hours a day in Santa Barbara, California. A 300- or 1200-bit-per-second modem is required, and the system permits both up- and downloading. For more information, call the CoCo Corner BBS at (805) 687-9400.■

Discover FORTH

Thom Hogan
Osborne/McGraw-Hill
Berkeley, CA: 1982
140 pages, softcover,
$14.95

Reviewed by
Paul E. Hoffman

Although the microcomputer industry has adopted BASIC as a standard language, it is by no means the final word on languages. More than five other languages are becoming popular for specific applications and users, and FORTH is among the most recent.

Thom Hogan's *Discover FORTH* is not simply another language book because FORTH is not at all just another language. The concepts in FORTH programming are very different from those used in BASIC programming, and Hogan introduces FORTH programming innovatively in a nontechnical fashion. Hogan has previously authored *Osborne CP/M User Guide.*

To a BASIC programmer, FORTH programs resemble a long list of subroutine calls with few procedural steps. Once a procedure is defined in FORTH, it can be used anywhere else, so that a procedure can call any other procedure or even call itself. This is quite a different technique than programming in BASIC, and *Discover FORTH* holds the reader's hand, so to speak, throughout this learning process.

Why FORTH?

Although the FORTH language has been available in the microcomputer market for a few years, this is the first book to answer the question, Why should I be interested in another language, and why should it be FORTH? Hogan points out the uniqueness of FORTH programming, such as relying on a memory stack and the absence of GOTO statements. He describes how FORTH is better suited to programming than other languages.

Several books on the market are introductions to FORTH, but *Discover FORTH* has more for the novice FORTH user. Hogan has kept in mind the fact that microcomputer users are not always oriented to bits and bytes, and many have programmed only in BASIC. The book thus has a friendly tone without talking down to people who know other languages but want a flavor of FORTH.

Hogan also realizes the advantages of humor in teaching. Without trying to be a laugh a minute, he succeeds in making an otherwise dry and sometimes complex language interesting. A few section headings are puns, as in "It's His FORTH Operation, Doctor" for the section discussing arithmetic operators, and "I/O You an Explanation" for the section describing how to use input/output operations.

Using FORTH

Hogan suggests that the FORTH language is one that should be learned by doing. The author gives short examples of programs that include the operations being described. Each example is shown in its environment so that the reader can easily follow the sequence. Since FORTH is an interactive language, results can be viewed at any time throughout the entire programming process. Because FORTH programs look very different from BASIC, Hogan recommends that the reader verify the results of steps explained in the book.

Two of the most difficult FORTH concepts to teach are the use of the stack and the greatly reduced use of variables. Most programmers familiar with procedural languages such as BASIC have never used stacks and frequently use variables in their programs. Thus, FORTH's techniques for storing information during program execution need special attention.

Discover FORTH devotes chapters to each of these concepts early in the book to give the reader a clearer idea of why FORTH might seem strange. While many authors cover these basic FORTH structures only briefly, Hogan emphasizes them early enough so that you can be sure you understand them before reading on. He succeeds in explaining the concepts through the use of illustrations and real-world analogies.

Examples in FORTH

One problem with *Discover FORTH* is the rarity of examples. Although Hogan fully explains each FORTH word (which is the equivalent of a BASIC command), he offers only three or four small programs to show how to actually develop something with the language. This makes it harder to decide if you're interested enough in the language to buy the book. However, the examples he does provide are clear and explained fully in the text.

Regardless of Hogan's underuse of example programs, you will certainly know what each part of FORTH does by the time you finish reading the book. Since FORTH rarely uses variables (at least, not in the way they are used in BASIC), it is a major task to describe the structure of the language and diagram the actions of particular FORTH words.

The Book's Structure

The book is broken into three areas: the low-level concepts and history of FORTH, how words in FORTH make things happen, and how to make your computer run your FORTH programs. Because each area is covered thoroughly, the reader is left with the impression that the author said everything he wanted to in a small amount of space. The book demonstrates how FORTH can be taken out of its current jargon-riddled state and be tailored to the individual programmer. Hogan stresses this throughout the book and takes some of the edge off the strange words chosen for some FORTH concepts.

In essence, *Discover FORTH* is a practical book for anyone who is interested in a new and very different language for his microcomputer. It is written on a level that anyone can appreciate, and it shows FORTH's strengths as well as its weaknesses. As the title implies, the purpose of the book is to exhort you to become involved in FORTH, and it does so in a way not found in other FORTH manuals. ■

Paul E. Hoffman, president of Proper Software (Suite 1024, 2000 Center St., Berkeley, CA 94704), writes manuals for microcomputer companies in the San Francisco area.

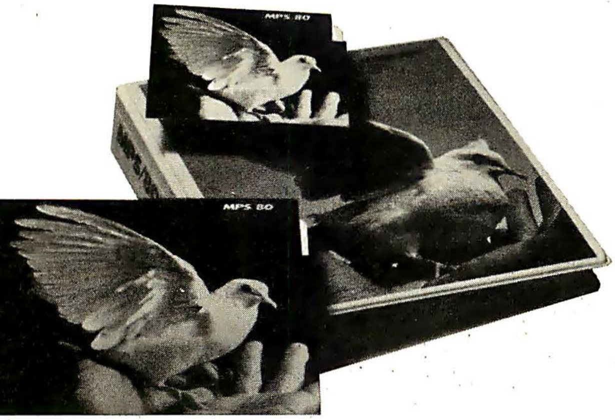
BYTE's Bits

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McGraw-Hill Book Company's Electronic Bookshelf is on air weekdays from 6 p.m. to 8 a.m. eastern standard time and for 24 hours on weekends. For a catalog of computer and electronic books, log on by calling (212) 997-2488. ■

What's New?

SOFTWARE



Magical Programming Language

MAGIC from Data Management Associates is a medium-level, portable programming language that creates applications programs without requiring a run-time package. The instruction set permits the creation and maintenance of machine-executable programs, and its file I/O capabilities support random, sequential, and ISAM file types. MAGIC has internal data areas that are said to be completely variable with buffers that are dynamically allocated for hardware and software efficiency. Other features include BCD arithmetic with up to 36 digits, simplified screen formatting and data editing, the ability to mix assembly language anywhere in source code, and total string-manipulation capability.

MAGIC is available for CP/M-, 8086-, and 8088-based systems. It costs $795, which includes a cross-referenced manual. For details, contact Data Management Associates Inc., POB 4340, Wilmington, DE 19807, (302) 655-8986.

Circle 510 on inquiry card.

Utility Lets You Edit Any Byte

Media Magician is a full disk-editing utility that lets you view, change, and save any byte, string, or sector anywhere on a floppy or hard disk. It provides simultaneous screen displays of the hexadecimal and ASCII representations of each byte. Editing can be done on either window, and all changes in one window are immediately made in the corresponding display. Media Magician uses single-character commands for such functions as printing out a sector, searching for a specific string, comparing two sectors, and moving sectors. Other features include help screens and the ability to use IBM PC color or monochrome graphics.

Media Magician works with the IBM Personal Computer and machines running MS-DOS version 2.0. It requires 64K bytes of RAM and an 80-column display. The price is $48.50, plus $1.50 for postage and handling. Contact Photon Software, 636 120th Ave. NE, Bellevue, WA 98005, (800) 426-2675; in Washington, (206) 451-8272.

Circle 502 on inquiry card.

Simulation Environment Is Interactive

GPSS/PC is a simulation environment designed for interactive use on the IBM Personal Computer. Using GPSS/PC, you can predict the effects of managerial or engineering decisions on complex real-world systems. The software features more than 70 blocks and commands, 45 SNAs (system numerical attributes), clock and internal precisions limited only by the amount of computer memory, full-period 32-bit random-number generators, and the ability to include exponents, cosines, tangents, and logarithms in complex expressions. All blocks and SNAs can be accessed from within the program or entered interactively through the keyboard during simulation. You can mix SNAs into complex expressions and construct accurate probability distributions without using GPSS functions.

GPSS/PC will expand beyond a megabyte of memory if your DOS permits. Models typically require approximately 0.003 second per block entry on the IBM PC's 4.77-MHz 8088 processor. Dynamic allocation of individual entry types and indirect addressing through transaction parameters are supported. The following are limited solely by the amount of memory in your computer: parameters per transaction, random-number generators, chains occupied by a transaction, and internal accumulators. Operator conveniences include on-line helps, command recognition, keystroke-error correction, assignable function keys, automatic spacing, cursor prompting, and a built-in line editor.

Production quantities of GPSS/PC will be available in May. For information on licensing fees, contact Minuteman Software, POB 171, Stow, MA 01775, (617) 897-5662.

Circle 504 on inquiry card.

Pro-Accountant for DEC Professional

Deccomp's Pro-Accountant General Ledger accounting software operates on the DEC Professional 350 microcomputer. A novel feature of this system is its multitasking capability, which lets you set up posting of journals or generate and print reports in the background while continuing to use the keyboard for other tasks. Pro-Accountant can handle multiple companies and divisions on the same disk, and two years of detail is maintained with one year of budget amounts. When a report is generated, the profit account is automatically computed, which allows contribution income to be shown by individual or all departments. Pro-Accountant is menu-driven, and it fully supports all the Professional 350's special function keys.

Pro-Accountant costs $1500. For complete details, contact Deccomp Inc., 14752 Sinclair Circle, Tustin, CA 92680, (714) 730-5116.

Circle 500 on inquiry card.

Sophisticated Word Processor for PC

Volkswriter Deluxe is a sophisticated word processor for business and professional users of the IBM Personal Computer and its compatibles. When used with a database manager, such as dBASE II, Volkswriter lets you compile a mailing list, send personalized form letters, and print labels. Through the use of virtual memory, document sizes can be as large as 1 megabyte. Page endings, underlining, boldface, double strike, and strike-throughs are shown on screen. Special features include horizontal scrolling up to 250 characters, chapter-end footnotes, and proportional spacing.

This program comes preconfigured for 16 printers. Multiple fonts and color monitors are supported. It can handle multilingual keyboards and printer character sets and work with Lotus 1-2-3, Visicalc, and a variety of spelling checkers. Among the additional word-processing functions provided with Volkswriter are single-keystroke editing, on-screen reference guide, variable margins, superscripts, and subscripts.

Volkswriter Deluxe costs $285. For more information, contact Lifetree Software Inc., Suite 315, 411 Pacific St., Monterey, CA 93940, (408) 373-4718.

Circle 501 on inquiry card.

Sort/Merge Co-routine Operates Interactively

Co-Sort from Information Resources is a general-purpose sort/merge co-routine for on-line report generators, database managers, mailing lists, and compilers. Co-Sort operates interactively with a calling program or off-line for utility sorting and merging. Its time-sorting algorithm is accessed interactively by programs in ASM, CBASIC, MBASIC, Pascal, and other languages that can call a machine-language routine. Any number and type of filters, inputs, keys, and outputs are permitted with Co-Sort, including exception processing. I/O records can be transferred in files or directly in memory without physical I/O.

Co-sort runs under CP/M-80, CP/M-86, or MS-DOS. It costs $200, which includes programs and documentation in ASM and BASIC. For more information, contact Information Resources, POB W, Manhasset, NY 11030, (516) 365-7629.

Circle 507 on inquiry card.

Family Medical Program

Navic Corporation's Family Medical Advisor is an informational. and educational program that analyzes overt symptoms and identifies the probable cause of a medical condition. This program prompts you with a series of yes-or-no questions to establish a pattern. It then analyzes your responses and lists related disorders with similar symptoms in descending order of probability. In the database are details on nearly 200 common illnesses.

Family Medical Advisor runs on an Apple II Plus with 48K bytes of memory and a disk drive. For more information, contact Navic Corp., POB 14727, North Palm Beach, FL 33408, (305) 627-4132.

Circle 508 on inquiry card.

LISP System for IBM PC

Gold Hill Computers has announced the availability of Golden Common LISP (GCLISP) for the IBM Personal Computer. GCLISP offers a full range of data types, including infinite-precision integers, floating-point numbers, arrays, character strings, lists, structures, and symbols. It supports object-oriented programming. GCLISP has been enhanced with such programming development aids and operating extensions as a full-screen intelligent editor, multitasking capabilities, macro instructions, memory allocation, garbage collection, and stream-oriented I/O.

Gold Hill Computers plans to support the iAPX286 and to release a GCLISP compiler. GCLISP requires PC-DOS 2.0 or greater and 256K bytes of memory. The suggested price is $375, which includes comprehensive documentation. Dealer inquiries are invited. For further information, contact Gold Hill Computers Inc., 163 Harvard St., Cambridge, MA 02139, (617) 492-2071.

Circle 505 on inquiry card.

Accounting Software

The Certified Accounting System is an integrated accounting package for microcomputers running under CP/M-80, CP/M-86, MS-DOS, and PC-DOS. A key feature of this software is that it supports end-user customization of input screens, files, and report formats. Certified Software lets you tailor input screens to your business documents and forms, change numeric and alphanumeric field lengths and types, design new printed reports to replace or supplement standard reports, modify program print positions to match print positions on existing forms, and create vertical accounting packages targeted at specific needs. This package has received independent third-party review and certification from Touche Ross & Co., an international accounting firm.

The Certified Software package comprises five basic accounting modules: general ledger, accounts payable, accounts receivable, inventory, and payroll. In addition, a customizing kit is offered. All the modules are available with or without the ability to automatically update the general ledger whenever new data are entered into any module. Without the automatic general-ledger update, the suggested retail price for each module is $195. Individual modules with the update feature are $295. A required system guide is $45. The customizing kit is $145. Dealer inquiries are welcome. For the name of your nearest dealer, contact Certified Software Inc., 9900 Southwest Wilshire St., Portland, OR 97225, (503) 297-8666.

Circle 503 on inquiry card.

Business Graphics for Microangelo

The DaVinci Business Graphics package from Professional Research Consultants lets you create presentation-quality charts and graphs using the Scion Microangelo Color System. From two to eight Microangelo bit planes can be supported by DaVinci to generate 4 to 256 colors per image. This package handles pie charts, exploded pie charts, bar and three-dimensional bar charts, linear pie charts, and line graphs. A menu-driven interactive data-entry program, DaVinci allows you to enter data values, titles, color selections, and axis-scale information. Data can come from user-written programs or programs capable of generating ASCII data files. All parameters and options for a particular image are stored in a work space that can be loaded for displaying or modifying the graph.

DaVinci runs on any Z80-based S-100 system compatible with CP/M 2.2. It costs $650. Additional details are available from Professional Research Consultants, 12832 Augusta Ave., Omaha, NE 68144, (402) 330-5433.

Circle 506 on inquiry card.

Integrated Package for Business

An integrated software package for business people using the DEC Professional 350, Propel is distributed by Pro Computing. Propel's applications are divided into three categories: telephone communications, written communications, and number processing. Its telephone communications capabilities are made up of a telephone directory with autodial functions, a telephone-call notebook, and an answering and message service. For writ-

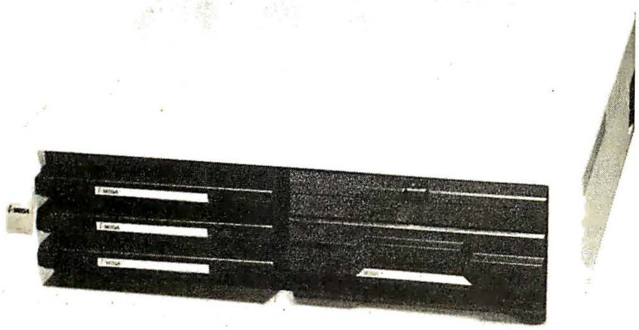
ten communications, Propel offers word processing, electronic mail, and meeting and reading notebooks. A spreadsheet and graphics constitute its number-processing abilities. In addition, Propel enables the Professional 350 to emulate DEC and IBM terminals for communicating with mainframe computers.

Propel can operate at four different levels of sophistication. Each level offers additional features for customizing applications. The software uses dedicated function keys, simple menu hierarchies, single-keystroke commands, and a consistent set of commands across all applications. Data transfers between applications are said to be simple. On-screen prompts for each menu option and help screens assist users.

Propel is available with or without the telephone functions for $1195 or $950, respectively. A toll-free hot-line number supports users. For full details, write to Pro Computing Inc., Suite 3314, One Penn Plaza, New York, NY 10119.

Circle 509 on inquiry card.

MASS STORAGE



Fluid Dynamics Boosts Storage Capacities

Iomega's engineers have adapted eighteenth-century Swiss mathematician Daniel Bernoulli's principle of fluid dynamics to flexible-disk subsystems. Called the Bernoulli Box, the unit controls the movement of air around a flexible disk as it spins under the recording head. As the disk is enveloped by air, it rises to within 10 microinches of the head, creating a soft interface that permits high media density and rapid access. The average access speed is 30 milliseconds, and the transfer rate is 1 megabyte per second. The removable flexible-disk cartridge can handle 10 megabytes of formatted data. Cabinet dimensions are 5½ by 19½ by 18 ⁹⁄₁₀ inches.

The Bernoulli Box is available in 10- and 20-megabyte versions for the IBM PC XT and the Texas Instruments Professional Computer. The 10-megabyte unit, which is upgradable to 20 megabytes, has a $2695 suggested retail price. The 20-megabyte unit lists for $3695. The 10-megabyte upgrade kit is $1000. The disk cartridges cost approximately $60. Iomega also produces 5¼- and 8-inch cartridge drives capable of holding 5.2 megabytes of data. For complete details, contact Iomega Corp., 4646 South 1500 W., Ogden, UT 84403, (801) 399-2171.

Circle 514 on inquiry card.

5¼- and 3½-inch Winchesters Unveiled

Microcomputer Memories has unveiled a line of Winchester-disk drives aimed at the OEM and systems integrators market. The drives have ST-506 interfaces and offer 6.38 and 12.75 megabytes of storage and are available in half-height 5¼- and 3½-inch formats. These devices are engineered with such safety features as head-landing zones for recorded-data protection. The 12-megabyte unit features two oxide platters and manganese/zinc read/write heads, permitting less critical densities and enhancing reliability.

The single-unit price of the 12-megabyte Winchester drive in a 5¼-inch enclosure is $1300. OEM pricing can be less than $700. Address inquiries to Microcomputer Memories Inc., 7444 Valjean Ave., Van Nuys, CA 91406, (213) 782-2222.

Circle 512 on inquiry card.

Microfloppies Designed for Atari

A pair of 3-inch microfloppy-disk drives, the single-drive AMDC-I and the dual-drive AMDC-II, are compatible with Atari 400/800 and XL Series computers. Both units have an integral intelligent controller and DOS/XL operating system software. They can control up to four drives, each programmable for single- or double-density operation, and can be used in conjunction with 5¼-inch drives to boot Atari software. The media are Amdek's 3-inch cartridges, which feature an automatic shutter mechanism to protect against dust and fingerprints.

The AMDC-I provides 180K bytes of formatted storage. The AMDC-II gives you 180K bytes of double-density storage per side for a total of 360K bytes. (Note that you must manually flip the cartridge.) The suggested retail price is $599 for the former and $850 for the latter. The 3-inch cartridge media are $6.99 each. For full information, contact Amdek Corp., 2201 Lively Blvd., Elk Grove Village, IL 60007, (312) 364-1180.

Circle 511 on inquiry card.

Turbo-Disk Unveiled

The Turbo-Disk from New World Computer Company is a 5¼-inch Winchester-disk drive with a dozen read/write heads on each side of the disk. Its head slider assembly is mounted on a parallelogram that moves the read/write heads across a rotating disk in a purported 1/12th the time and distance of a single head. The Turbo-Disk provides an 8-millisecond access time for data under the heads and a 16-millisecond average access for remaining data. When not in use, the heads are locked above the disk surface, protecting data.

Turbo-Disk comes in configurations for the OEM and high-performance end-user markets. The first OEM model is a half-height 5-megabyte fixed-disk drive priced at $1800. A 5-megabyte half-height fixed-disk drive enhanced with 5 megabytes of removable storage is available for $2325. For end-users, the Turbo-Disk can be purchased as a 20-megabyte subsystem. This system features 5 megabytes fixed and 5 megabytes removable storage, plus 10 megabytes of additional storage in the form of two removable cartridges. It's provided with a power supply, disk controller, connecting cables, utility software, and a host interface that's compatible with IBM, Apple, DEC, S-100 bus, and Multibus systems. It lists for $4950, with

volume discounts available. Additional cartridges and an ST506/412 interface are optional. New World Computer Co. Inc., 6624 Owens Dr., POB 1479, Pleasanton, CA 94566, (415) 463-0330.

Circle 515 on inquiry card.

Drive Stores 3.2 Megabytes at 170 TPI

MPI has announced Megadrive, a 5¼-inch floppy-disk drive with an unformatted storage capacity of 3.2 megabytes at 170 tpi. Standard features include back-up and program-load capabilities, 3-millisecond track-to-track access time, and a closed-loop positioning system designed to adjust the drive to media distortions caused by heat or humidity. Megadrive has a microprocessor coupled with a stationary quad sensor and a mylar reference scale that enables it to sense track locations and guide the head to the intended track, eliminating the risks associated with higher tpi densities. It's plug-compatible with existing 8-inch controllers with ST 850 interfaces, and it can read 48- and 96-tpi floppy disks. Mean time between failures is 8000 hours under typical usage.

OEM evaluation units are priced at $500. Contact MPI, 9754 Deering Ave., Chatsworth, CA 91311, (213) 709-4202.

Circle 516 on inquiry card.

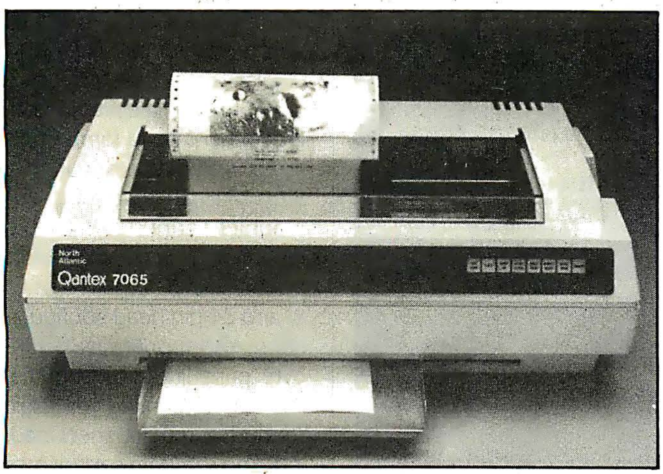
Subsystem Upgrades PC to XT Storage Capacity

Piiceon 's WHAMS 1-XT is a 10-megabyte Winchester-disk subsystem that upgrades the IBM PC to the storage capacity of a PC XT. The complete subsystem comprises a multifunction board equipped with an RS-232C asynchronous serial port and room for up to 256K bytes of RAM, a half-height drive, and a drive connector cable. It's hardware- and software-compatible with the IBM PC and PC XT and runs all versions of PC-DOS, including DOS 2.0, as well as utilities.

WHAMS fits into the IBM's second floppy-disk slot and requires two cable connections. It operates with the PC's power supply. Without RAM, WHAMS costs $2375. Each 64K-byte RAM is $90. For additional information, contact Piiceon Inc., 2045 Lundy, San Jose, CA 95131, (408) 998-4016.

Circle 513 on inquiry card.

PRINTERS



Qantex Compatible with Epson and Anadex ESC Codes

The Qantex Model 7065 serial dot-matrix printer is fully compatible with Epson and Anadex escape codes. Its operating speeds are 300 cps for draft copy; 250 cps, compose; 125 cps, near letter quality; and 65 cps, letter quality. In its dot graphics mode, this printer provides 144 by 144 bit-mapped dots per square inch at a repetition rate of 1500 dots per second per activated needle. Prominent print attributes include proportional spacing, right-hand margin justification, automatic underline, overprint and boldface, and downloadable fonts. The 7065 will store three letter-quality fonts on line before requiring a change of print wheels. Standard word-processing fonts are Trend and Courier; Emphasis, Cubic, Scientific, APL, Script, and Italics are offered as options.

The Model 7065 is controlled by a Z80A microprocessor. The built-in 4.7K-byte buffer is expandable. The printer's single-sheet feeder incorporates a combination roller-tractor that lets you use continuous or cut-sheet forms. DIP-switch activated Centronics parallel or RS-232C serial interfaces are provided. Data-rate capabilities range from 110 to 19,200 bps.

Diablo compatibility is optional. In single units, the Model 7065 is $1995. Purchasing information is available from North Atlantic Industries Inc., Qantex Division, 60 Plant Ave., Hauppauge, NY 11788, (800) 645-5292; in New York, (516) 582-6060.

Circle 517 on inquiry card.

Canon Unveils Three Printers

Canon U.S.A. recently introduced two near letter quality printers and a color ink-jet printer. The PW-1080A and the PW-1156A printers give you single-sheet insertion with roll, fan-fold, single-sheet, and multipart copy paper. They have a built-in, adjustable tractor feed, removable cartridge ribbon, and the ability to print four character styles on the same line. For high-resolution graphics, they provide N- by 16-dot matrix printing. Both operate at 160 cps. The PW-1080A prints 80 characters per line, and the PW-1156A can print 156 characters per line. Superscript, subscript, and international character sets are optional.

The PJ-1080A ink-jet printer can produce seven colors on paper and overhead transparencies. It has four character styles that it prints at 37 cps. The PJ-1080A has separate black and tri-color ink cartridges, high-resolution color-graphic printing of 640 dots per line, and automatic vertical and horizontal tabulation with page-length-per-inch setting. International character sets are available.

The suggested price for the PW-1080A is $595. The PW-1156A is $895, and the PJ-1080A is $795. For more specifications, contact Canon U.S.A., 1 Canon Plaza, Lake Success, NY 11042, (516) 488-6700.

Circle 518 on inquiry card.

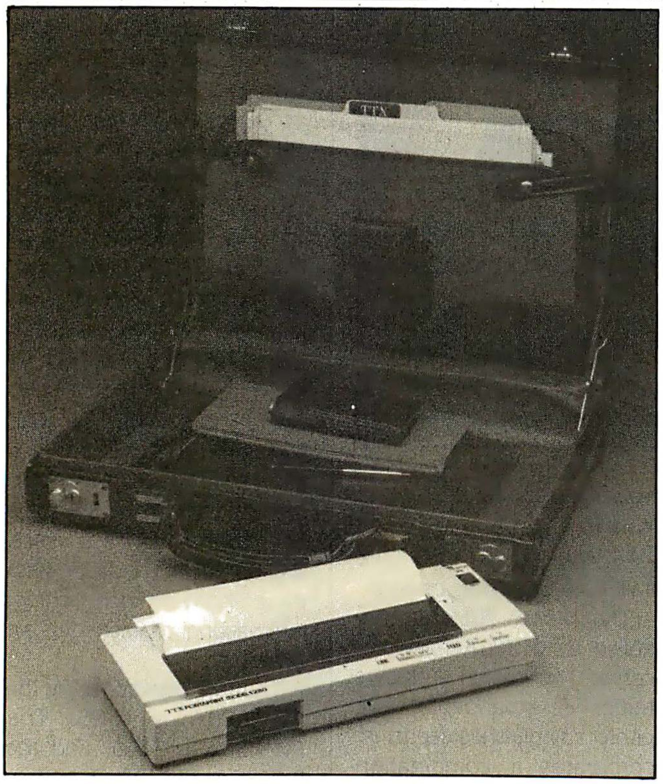
Color Printer for Atari

Axiom Corporation has introduced a multifunction, full-color printer that's compatible with Atari computers. The GP-700AT plugs directly into the Atari's serial port, eliminating the need for an 850 interface. It also permits daisy-chaining of cassettes and other

peripherals without the 850 interface. Alphanumerics, symbols, and graphics elements can be output at speeds of up to 50 cps, and as many as 25 colors can be penned with a single pass of the four-hammer print head. A cassette ribbon, inked with black, magenta, cyan, and yellow, allows color mixing without smearing. A data-compression/expansion system that scans each line to be printed for repetitive data to contract is said to send color information to the printer up to 100 times faster than conventional software.

The GP-700AT comes with a connecting cable and screen-dump programs. It lists for $599. A complete description is obtainable from Axiom Corp., 1014 Griswold Ave., San Fernando, CA 91340, (213) 365-9521.

Circle 519 on inquiry card.



Thermal Printer Complements Portables

The TTX 1280 Portaprint, a three-pound battery- and AC-powered thermal-matrix printer, complements your portable or hand-held computer. This bidirectional printer operates at 40 cps (batteries) and 80 cps (AC). Portaprint uses a 5- by 7-dot nonimpact print head to produce a variety of character sizes and densities, specialized letters, and line and dot-by-dot placements. It offers graphics capabilities, bold and shadow printing, and oversized characters. Portaprint has a condensed-printing mode that lets you expand its normal 80-column line so that 132-column spreadsheets can be printed on standard 8½- by 11-inch paper. Six-volt batteries provide 4000 to 5000 lines of print or approximately 2½ hours of operation.

The TTX 1280 Portaprint costs $199. An AC adapter is supplied. Production quantities will be available in the spring. For full details, contact Teletex Communication Corp., 3420 East Third Ave., Foster City, CA 94404, (415) 341-1300.

Circle 521 on inquiry card.

Multifunction Printer from Epson

Epson's LQ-1500, a multifunction serial dot-matrix printer, can run at speeds from 60 to 200 cps. This 136-column unit has built-in character sets that provide the 96 ASCII characters, 13 international sets, and 128 downloadable characters. Its 45 standard fonts implement Pica and Elite spacing in regular, enlarged, emphasized, and condensed formats. Proportional spacing in regular and enlarged formats and regular and enlarged super- and subscripts are provided. A 24-pin print head forms characters with matrices spanning 9 by 17 to 37 by 17 dots. For graphics printing, variable resolution from 60 to 240 dots per inch can be achieved using 8- and 24-pin head configurations. Also supplied are a 15K-byte print line image buffer, bidirectional printing with logic seeking, automatic sheet loading, and software control over intercharacter spacing, print size, and vertical and horizontal tabs.

Centronics 8-bit parallel, RS-232C, and IEEE-488/GPIB interfaces are available. The LQ-15000 retails in the $1200 to $1500 range. OEM discounts are offered. Contact Epson OEM Products Division, 3415 Kashiwa St., Torrance, CA 90505, (213) 533-8277.

Circle 523 on inquiry card.

Smith-Corona Unveils Matrix Printers

Smith-Corona recently introduced a line of dot-matrix printers. At the high end is the D-300, which offers a printing speed of 140 cps and a column width of 132 characters (10 pitch). Among the key features of this near letter quality printer are six pitches, emphasized and elongated print, proportional spacing, italics, bit-mapped graphics, character descenders, superscript, subscript, a 2K-byte buffer, and a 96-character ASCII set for printing in six foreign languages. Friction and tractor feed, bidirectional printing, shortline seek, and vertical and horizontal tabs are all standard. The character matrix ranges from 9 by 8 to 17 by 16 dots. Parallel and serial interfaces and self-test are supplied. The D-300 lists for $795.

The D-200 differs from the D-300 in that it operates at 120 cps and its column width is 80 characters per line at 10 pitch. The suggested retail price is $595.

The $395 D-100 prints an 80-column line at 100 cps. This parallel printer, which is furnished with most of the accoutrements of the D-300, has a full-line buffer capable of accommodating up to 132 characters. A serial interface is optional. Further information on these products is available from Smith-Corona, 65 Locust Ave., New Canaan, CT 06840.

Circle 522 on inquiry card.

Dot-Matrix Printer Supports Hi-Res Graphics

Apple's Imagewriter dot-matrix printer reproduces high-resolution graphics at speeds approaching 180 cps. The Imagewriter prints in a 7- by 9-dot matrix and provides variable resolution of 72 to 160 dots per inch. Such print features as variable pitch from 10 to 17 characters per inch, eight fonts, variable line spacing from 1/6 to 1/144 inch, and proportional font and line spacing are furnished. Fonts, underscores, superscripts, and subscripts can be mixed on the same line. Its bit-mapped graphics technology supports the Lisa's graphics capabilities.

The Imagewriter uses either friction-feed or adjustable-width pin-feed tractors. Paper sizes range from 3 to 10 inches wide. Single sheets, fan-fold continuous forms, roll stock, and precut labels are all acceptable. Four copies can be printed simultaneously.

The Imagewriter uses a standard RS-232C interface to connect directly with the Apple III or Lisa. The Apple Super Serial Interface card is required for the Apple II Plus and IIe. The suggested price is $675, which includes cables, applications manual, user guide, and software for printing high-resolution graphics. Contact Apple Computer Inc., 20525 Mariani Ave., Cupertino, CA 95014, (800) 538-9696; in California, (408) 996-1010.

Circle 520 on inquiry card.

SYSTEMS



128K Standard with Leading Edge PC

The Leading Edge Personal Computer is an IBM PC-compatible offering 128K bytes of memory and an integrated RS-232C serial port. Salient features include a 7.16-MHz processing speed, seven IBM bus-compatible expansion slots, a digital time-of-day clock with battery backup, an 83-key IBM-format keyboard, and twin 5¼-inch 320K-byte floppy-disk drives. A 12-inch green-screen monitor with an 80 by 25 display format is standard. Microsoft DOS 1.25, Microsoft GW BASIC, and the Leading Edge Word Processor are bundled with the system.

The Leading Edge Personal Computer has a suggested retail price of $2895. For further details, contact Leading Edge Products Inc., 225 Turnpike St., Canton, MA 02021, (800) 343-6833; in Massachusetts, (617) 828-8150.

Circle 529 on inquiry card.

Senior Partner for Portable Computing

Panasonic's portable Senior Partner uses MS-DOS 2.0 and is compatible with IBM PC hardware and software. It incorporates a built-in thermal printer, a double-sided double-density 320K-byte floppy-disk drive, and a 9-inch display in a single 28.7-pound case. It has 128K bytes of RAM (expandable to 512K bytes) and is based on the 16-bit 8088 chip. For mathematics processing, the Senior Partner has a spare socket for an 8087 processor.

The thermal printer has graphics capabilities and can be switched from 80 to 132 characters per line. The video display has a green background and an 80 by 25 format. The format is adjustable to 40 characters per line. Senior Partner carries an RGB monitor port and Centronics parallel and RS-232C interfaces.

The Senior Partner measures 18¼ by 13$\frac{3}{16}$ by 8¼ inches. It costs $2495, which includes six software packages. Contact Panasonic Co., One Panasonic Way, Secaucus, NJ 07094.

Circle 525 on inquiry card.

Turbodos System Carries Five Slaves

The QDP-400 TurboDOS multiuser system features a 6-MHz Z80B master central processor and up to five Z80A or Z80B slave processors. It comes with a standard 128K bytes of RAM, 128K bytes of RAM for each user, and a six-slot S-100 motherboard that accommodates double-height boards. Overall system speed is increased with a master controller DMA for disk and memory transfers. It's compatible with CP/M and MP/M applications software, and bank-switching of the operating system in master and slave operations provides a transient program area for applications programs. TurboDOS networking gives users access to disks, magnetic tape cartridges, printers, modems, and other peripherals.

The QDP-400 features Winchester hard-disk storage to more than 30 megabytes and a double-sided double-density 8-inch 1.2-megabyte floppy disk. Up to 12 RS-232C serial ports with optional networking communications through serial channels and two Centronics parallel ports are available. System prices start at $9995. Contact QDP Computer Systems, 10330 Brecksville Rd., Cleveland, OH 44141, (216) 526-0838.

Circle 527 on inquiry card.

Single-Board Computer Controller

The Model 83-230 single-board computer from John Bell Engineering is designed for use as a print spooler or as a controller in security systems or robots. This 6502-based board has 55K bytes of dynamic RAM, 8K bytes of EPROM, four parallel ports, one serial RS-232C port, and four timers. It measures 4½ by 6½ inches and uses the 44-pin AIM bus. A 2716 monitor EPROM is available as a $19.95 option. The bare board is $49.95. The assembled and tested version is $299.95. Full documentation is supplied.

A universal interface suitable for laboratory experiments and industrial-control applications is also available from John Bell Engineering. Designed for the IBM Personal Computer, the Model 83-064 has nine parallel 8-bit ports, 16 analog input ports, a timer, interrupt circuitry, and a prototyping area. It uses three 8255 programmable pe-

ripheral-interface chips and an ADC-0817 analog input device. Analog inputs are 0 to 5 volts; the conversion time is approximately 200 microseconds per channel. The timer-oscillator runs at 32768 Hz and provides a total of 25 different frequencies. All I/O ports attach through 16-pin ribbon cables with DIP connectors. With documentation, the 83-064 costs $299.95, assembled and tested. Contact John Bell Engineering Inc., 1014 Center St., San Carlos, CA 94070, (415) 592-8411.

Circle 530 on inquiry card.

Headstart Offers Up to 1 Megabyte RAM

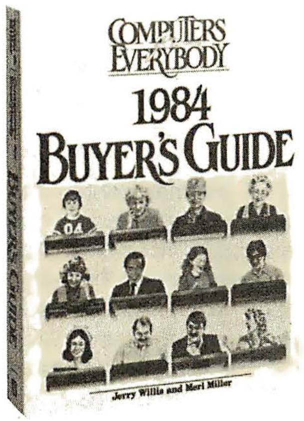
Intertec's Headstart can be equipped with 1 megabyte of memory. Headstart comes with dual 8/16-bit microprocessors, 3½-inch 500K-byte (unformatted) floppy-disk drives, and built-in multiuser networking capabilities. System interfaces comprise coaxial communications, RS-449/RS-232C serial communications port, and a Centronics-type parallel port. A detached keyboard, a 12-inch nonglare screen, IBM PC compatibility, and RAM disk emulation capabilities are some of Headstart's highlights. It employs the 16-bit Intel 8088 and Zilog's 8-bit Z80A, respectively running MS-DOS and CP/M-80.

Up to 255 Headstarts can be linked with Intertec's high-speed coaxial interface. Networking capabilities include electronic mail and software file protection. A 5¼-inch 20-megabyte Winchester unit and an 8-inch Winchester with 25 megabytes of fixed storage and 25 megabytes of removable storage are offered as network enhancements.

Headstart can be obtained in 128K-, 500K-, and 1-megabyte versions. In ascending order, base prices are $1895, $3495, and $4495. Software utilities and 5¼-inch floppy-disk drives are optional. For details, contact Intertec, 2300 Broad River Rd., Columbia, SC 29210, (803) 798-9100.

Circle 524 on inquiry card.

PUBLICATIONS



Computers for Everybody

Computers for Everybody 1984 Buyer's Guide by Jerry Willis and Merl Miller carries up-to-date information on microcomputers. It describes 143 computers in detail ranging from keyboard design to available software. Topics covered include an introduction and guide to hardware and software, steps in selecting a computer, and portable computers.

Computers for Everybody is available in paperback for $19.95. Contact Dilithium Press, Suite 151, 8285 Southwest Nimbus, Beaverton, OR 97005, (800) 547-1842; in Oregon, (503) 646-2713.

Circle 533 on inquiry card.

Statistics Program Directory

An Annotated Directory of Statistical and Related Microcomputer Software for Socio-Economic Data Analysis by Kelly, Stevens, Stilwell, and Weber is available from Michigan State University. This directory describes more than 260 programs and places a special emphasis on those packages written for Apple, IBM, and CP/M systems. It also identifies and provides information on 30 generalized statistical packages.

The 165-page directory costs $7. Copies can be obtained from the Department of Agriculture, Agriculture Hall, Michigan State University, East Lansing, MI 48824.

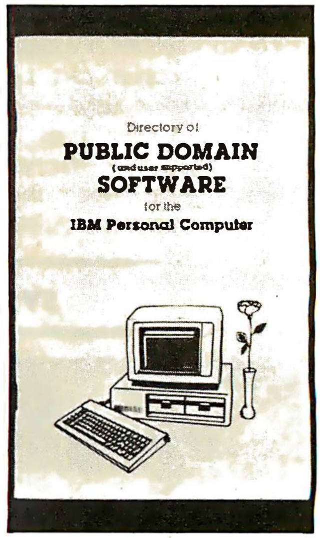
Circle 532 on inquiry card.

Independent Maintenance Service Guide Offered

C/ESN Publications has introduced its first annual Guide to Independent Service, a directory of companies offering third-party on-site maintenance and depot repair to OEMs and end users. The directory contains a geographical index of service companies and provides such information as number of employees, service revenues, years in business, and hardware and software maintained. Services offered include depot and on-site repairs, remote diagnostics, repair of communications equipment, and operating-system and applications-software troubleshooting. Such management innovations as centralized dispatch, telephone support, and automated parts inventory are noted. Also included in the directory are details of each company's service contracts and feature articles of interest.

The cover price for the Guide to Independent Service is $19.95. For more information, contact C/ESN Publications, POB 428, Peterborough, NH 03458, (603) 924-9457.

Circle 536 on inquiry card.



100 Plus Public-Domain IBM Programs

A catalog listing more than 100 public domain and user-supported programs for the IBM Personal Computer has been published by the PC Software Interest Group. Programs listed include financial and stock market analysis, word processing, communications, databases, BASIC utilities, graphics, spreadsheets, and print spoolers.

Copies of the book are available for $2.95 plus $1 for shipping. A set of the 10 most popular programs on disk costs $59. The complete set of 75 programs on disk is $439. Contact PC Software Interest Group, Suite 130R, 1556 Halford Ave., Santa Clara, CA 95051, (408) 247-6303.

Circle 534 on inquiry card.

Graphics Market Subject of Directory

You can locate information on the computer graphics industry in Computer Graphics Marketplace 1983–84. Edited

by John Cosentino, this book provides a listing of manufacturers, consultants, services, professional organizations, educational programs, conferences and conventions, and publications geared toward the graphics industry. Each entry includes names, addresses, telephone numbers, titles, and descriptions of each company's products or services. Product and geographical indexes augment the presentation.

This 102-page paperback costs $32.50. It's available directly from the Oryx Press, 2214 North Central, Phoenix, AZ 85004, (602) 254-6156.

Circle 535 on inquiry card.

Manual Experiments with Hero

Heath's Robot "HERO"; 68 Experiments: Fundamentals and Applications by Howard Boyet covers the basics behind controlling all of the Hero I's inputs, outputs, and applications. This 160-page book covers the Hero's use in such areas as industrial manufacturing, security systems, and home education. Its objective is to teach you how to become a robot innovator, capable of conceiving and implementing programs to control the Hero in a variety of applications. Topics addressed include machine-language control of inputs/outputs, user-dedicated keys, how to write an interpreter behind any higher robot language, and using Hero's motion-detection and range-measuring capabilities.

Heath's Robot "HERO" costs $21.95. For more information, contact Microprocessor Training Inc., 14 East 8th St., New York, NY 10003, (212) 473-4947.

Circle 531 on inquiry card.

FOREIGN



Home Computers With Stereophonic Sound

The Enterprise 64 and 128 Home Computers from Elan Computers Ltd. have stereo sound capabilities and 256 colors. Distributed in 64K- or 128K-byte versions, the Enterprise comes with a 69-key full-travel keyboard, a built-in joystick, color and black-and-white video outputs, a 56 by 84 display format, the ability to display text and graphics simultaneously, and an integral word processor with wordwrap, justification, text centering, and paragraph moving. Cassette, RS-423 serial, and Centronics-type parallel interfaces are standard, and a cartridge slot and an expansion connector are furnished. Enterprise is equipped with a network scheme that permits up to 32 computers to communicate and share resources. Cassettes or 3½-inch microfloppy-disk drives serve as mass-storage devices.

A fully structured programming language based on BASIC and enhanced with special operation commands and graphic- and sound-control facilities is supplied. Video and strategy games, educational programs, and programming aids are available. For complete details, contact Elan Computers Ltd., 31-37 Hoxton St., London N1, England; tel: 011441 739 4282; Telex: 22717 ELCOM G.

Circle 540 on inquiry card.

Drafting System Introduced

Datagraph has introduced a computer-aided design and drafting system that's built around an IBM PC or IBM PC XT and designed to serve as a tool for creating technical drawings, circuit diagrams, building plans, sketches, and illustrations. It features a 20-inch high-resolution graphics monitor, a video controller with 512K bytes of RAM, 1024- by 1024- by 4-pixel graphics, a mouse or digitizer tablet, and a drum or flatbed plotter. Elements such as lines, circles, arcs, rectangles, polygons, and text can be entered from a graphics tablet. Users can create and store elements. Drawings can be saved for manipulation or hard-copy printouts. Including the IBM, prices for the system range between DM 40,000 and DM 55,000, depending on configurations. Contact Datagraph GmbH, Giessener Str. 27, D-6302 Lich 1, West Germany; tel: 0 64 04/20 71; Telex: 48 28 90 video d.

Circle 537 on inquiry card.

Ball-Bearing Carriage Eliminates Noise

The Edcom slim-line floppy-disk drive uses a ball-bearing carriage to eliminate the noise and friction generated from a sliding read/write head. Edcom features a direct-drive brushless spindle motor, an automatic disk-ejection mechanism, a continuous band positioner, and ceramic heads. Memory capacity is 250K bytes double density and 125K bytes single density. The double-density transfer rate is 250k bits per second, and the single-density rate is 125k bits. Track density is 48 tpi, and track-to-track access averages 6 milliseconds. It works with Apple DOS, CP/M, and Pascal. Edcom measures 5.75 by 1.66 by 8.1 inches. For complete details, contact EDP Resources Co. Ltd., Number 5, 2/F., Newport Centre Phase 2, 116 Ma Tau Kok Rd., Tokwawan, Kowloon, Hong Kong; tel: 3-342405-8; Telex: 37449 ACTEL HX.

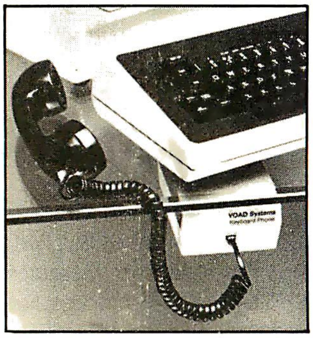
Circle 539 on inquiry card.

Commodore Speech Unit

The Commtalk speaker synthesizer for the Commodore 64 and VIC-20 has a virtually unlimited vocabulary. It operates independently, affecting neither your computer's normal sound functions nor its BASIC language. Commtalk uses allophones, which are the variants of individual phonemes, to construct words. You can access speech directly through BASIC commands and create a library of words with strings. The synthesizer has the ability to talk with the continuous execution of a BASIC program. Speech is output through your monitor. Commtalk connects directly to the Commodore, leaving free its cartridge slot.

Commtalk comes with a program cassette and manual. It costs £39; the PET version is £45. Contact Andor Systems, 28 Hillside Dr., Rathfarnham, Dublin 14, Ireland; tel: 01-900107.
Circle 538 on inquiry card.

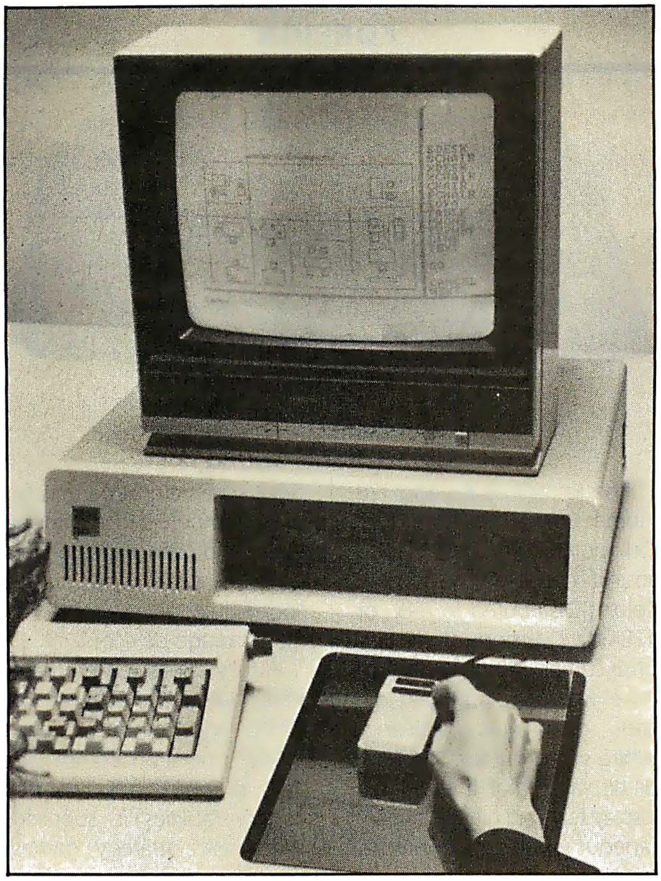
PERIPHERALS



Phone Replacement Allows High-Speed Dialing

The Voice Oriented Auto Dialer, or VOAD, Keyboard Phone replaces standard rotary-dial or Touch Tone telephones and allows high-speed automatic dialing from a computer keyboard. VOAD permits detailed call recording, convenient access to such telecommunications systems as MCI or The Source, programming of call restrictions into a host computer, and, with the appropriate software, the selection of the most cost-effective call placement.

VOAD draws its power from the telephone line. It automatically selects Touch Tone or pulse modes and offers redialing capabilities. VOAD connects to an RS-232C port and comes with an RJ-11 jack for hook-up to a handset, headset, or speaker phone. It costs $199.50; quantity and OEM discounts are available. Contact VOAD Systems, Suite 227, 8570 Wilshire Blvd., Beverly Hills, CA 90211, (213) 550-0629.
Circle 543 on inquiry card.



Mouse and CAD System Introduced

The Optomouse/AutoCAD package from USI Computer Products combines a digital mouse with a drafting and design software system. The Optomouse operates on a desktop grid and is accurate at speeds of up to 20 inches per second. It has four control buttons and is about the size of a deck of cards.

AutoCAD offers a variety of design and drafting applications ranging from architectural and landscaping drawings to drafting for mechanical, electrical, chemical, civil, and structural engineering. It lets you create and edit drawings of any size and scale. Drawings can be saved to disk, and complete drawings or combinations of design elements can be moved, copied, modified, erased, rotated, or rescaled through commands entered by the mouse or keyboard.

The Optomouse/AutoCAD works with the IBM Personal Computer and its compatibles. The retail price is $1200. For information, contact USI Computer Products Inc., 71 Park Lane, Brisbane, CA 94005, (415) 468-4900.
Circle 544 on inquiry card.

Single-Dot Editing with Light Pen

Magellan Computer's Light Pen System for the Apple II Plus allows single-dot editing on the Apple II Plus or IIe's high-resolution screen. The Light Pen has push-button control over drawing operations. It comes with an electronic module that connects to the computer's game I/O port. This technique is transparent and allows game paddles, joysticks, and other peripherals to occupy the port as well.

Two programs are supplied: Quick-Draw lets you create and edit presentation-quality graphics; Amper-Pen lets you incorporate light-pen operations into Applesoft BASIC programs.

The Magellan Light Pen System costs $189.95, including software and documentation. It's available from Magellan Computer Inc., Suite D, 4371 East 82nd St., Indianapolis, IN 46250, (317) 842-9138.
Circle 545 on inquiry card.

Digital Transmits to Computers

The Cybervision CV Series Digital-Camera detects an image and digitally transmits it to your computer for screening, printing, modification, transmission to another computer, or storage. A complete Digital-Camera includes an f1.6 lens with adjustable focus and f-stop, digital detector, an interface board, connecting cable, a tripod, and supporting software. Camera resolution is 128 by 256 pixels. The crux of this device is Micron Technology's IS32 OpticRAM.

The Cybervision CV Series Digital-Camera is designed for direct coupling to Apple, Commodore 64, IBM PC and PC XT, or Radio Shack TRS-80 computers. A version that can communicate with most microcomputers through an RS-232C cable is offered. The Digital-Camera may be ordered in kit form or completely assembled and tested. Prices begin at less than $300. For full particulars, contact Cybergen Systems Corp., 2070 Walsh Ave., Santa Clara, CA 95050, (408) 727-6766.
Circle 541 on inquiry card.

What's New?

Dual-Channel Chromatography for Apple

A full chromatography system for the Apple II is available from Anadata Inc. The Chromcard II, a 17-bit dual-channel A/D converter, comes with 128K bytes of RAM and necessary hardware and software. Data is acquired and displayed from two independent chromatographs and then analyzed at speeds of up to 40 points per second. A finished analytical report and graphic data can be output after peak detection and integration. If automatic selection is inappropriate, you can impose your own baseline. Methods and data can be stored on disk for retrieval and reprocessing.

Chromcard II costs $2450. For more information, contact Anadata Inc., 516 North Main St., Glen Ellyn, IL 60137, (312) 858-9606.

Circle 542 on inquiry card.

MISCELLANEOUS

Joystick Has ASCII Output

Turbo Stick is a high-pointing-speed joystick with full RS-232C ASCII output. Produced by the KA Design Group, Turbo Stick offers high resolution (i.e., one part in 4096) and dual fingertip-operated microswitches that let you alternate between an absolute mode with high pointing speed and a rate mode with high resolution. The switches can be redefined under software control to perform different functions.

Turbo Stick is suitable for graphics and instrumentation systems. It's priced at $395. OEM discounts are available. For details, contact KA Design Group, 6300 Telegraph Ave., Oakland, CA 94069, (415) 654-6300.

Circle 555 on inquiry card.

RS-232C Adapters

Ora Electronics designed the Data Spec ARS232AM adapter to convert a 25-pin RS-232C female connector to a male connector and the ARS232AF to perform the reverse function. These adapters are fully shielded to standards that are said to exceed FCC requirements. They incorporate a PVC molding to ensure maximum integrity and durability under adverse conditions. All 25 RS-232C pins are connected, making these adapters compatible with virtually all equipment. For more information, contact Ora Electronics, 18215 Parthenia St., Northridge, CA 91325, (213) 201-5848.

Circle 554 on inquiry card.

Cable Tester Has Remote Indicator

The Datacom RS-232C Cable Tester with remote indicator is a pocket-sized, battery-powered unit for testing and verifying cable configurations. Cables can be tested in either Step or Scan modes, and the Tester has 50 LEDs that indicate connections on each end of the cable. Three additional LEDs indicate Open, Short, or Continuity for each connection of the cable under test. Cable connectors are dual male/female 25-pin D-type, which allow any configuration of RS-232C cable connectors to be tested. The remote indicator lets you test and verify operations on installed cables. The Tester weighs 8 ounces, and the remote indicator is 3 ounces.

The suggested retail price for the Datacom Cable Tester is $399. For a complete product brochure, contact Datacom Northwest Inc., 11300 25th Ave. NE, Seattle, WA 98125, (206) 363-5805.

Circle 553 on inquiry card.



Datalife Detects Drive Problems

The Datalife Disk Drive Analyzer from Data Encore detects common disk-drive problems in Apple and IBM computers. Datalife runs four tests: disk alignment, disk clamping, write/read accuracy, and disk speed. It produces a display that indicates required adjustments and repair areas. System disassembly is not required. The entire test sequence takes only a few minutes.

The Datalife Disk Drive Analyzer comes on a 5¼-inch floppy disk. The suggested retail price is $39.95. For more information, contact Data Encore, 585 North Mary Ave., Sunnyvale, CA 94086, (408) 720-7400.

Circle 552 on inquiry card.

Where Do New Products Items Come From?
The information printed in the new products pages of BYTE is obtained from "new product" or "press release" copy sent by the promoters of new products. If in our judgment the information might be of interest to the personal computing experimenters and homebrewers who read BYTE, we print it in some form. We openly solicit releases and photos from manufacturers and suppliers to this marketplace. The information is printed more or less as a first-in first-out queue, subject to occasional priority modifications. While we would not knowingly print untrue or inaccurate data, or data from unreliable companies, our capacity to evaluate the products and companies appearing in the "What's New?" feature is necessarily limited. We therefore cannot be responsible for product quality or company performance.

RIBBON RE-INKERS

Introducing the **Pika-Ink**™, an incredible new device which extends the life of your fabric printer ribbons by a factor of TEN! Works with any fabric ribbon with ½-inch or narrower width. Automatically re-inks your ribbons either on or off the printer for consistent dark black print. Pays for itself on the first ribbon!

The **Pika-Ink**™ is a kit which includes • Stainless steel ink reservoir • ball bearing assembly • transfer felts • 115v 60Hz electric motor • power cord • special computer ribbon ink (extra ink available). Comes with complete instructions. Requires assembly and fabrication with hand tools.

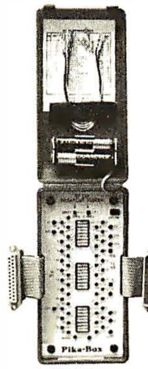
	each	3+	10+
Pika-Ink kit	$89	$84	$78

TERMINALS & PRINTERS

Micro-Term E301	$875	Qume QVT-108	$850
Visual 55	$850	Qume Sprint 11/40	$1495
Visual 102	$1050	Sprint Interface	$90
Qume QVT-102	$675	Sprint Tractor	$235

RS-232 BREAKOUT BOX

The **Pika-Box**™ RS-232 I/O tester is the most advanced breakout box on the market today. An absolute necessity for anyone who uses or works with RS-232 peripherals, interfaces, or data lines. Saves hours of aggravation. Available in standard or deluxe tri-state models. **Lifetime warranty!**



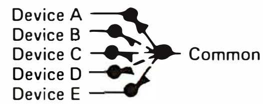
- 25-pin male DCE and female DTE connectors.
- Individual LED's monitor pins, 2, 3, 4, 5, 6, 8, 15, 17, 20, 21, 22, 25, plus MARK and SPACE.
- 24 DIP switches allow signal lines to be individually interrupted.
- 25 test pins for monitoring or cross patching with included jumpers.
- Tri-State model displays signals as high, low, or invalid.
- Fits in shirt pocket. 2.9"x5.5"x1.5", wt. 8 oz, with batteries (included).
- Fully assembled, ready to use.

	list	each	3+
Pika-Box	$199	$179	$174
Tri-State Pika-Box	$249	$219	$211

RS-232 SWITCHES SAVE 40% TO 80%!

Allows several devices to share a single RS-232 data line. Enhances flexibility of your system and puts an end to juggling cables. You've heard them called AB switches or T-switches, and they have outrageous prices!

The **Pika-Switch**™ is an economical alternative in kit form. You assemble it yourself and save 40% to 80%! Available in two models: 2-device (AB + common) with 3 female connectors, and 5-device (ABCDE + common) with 6 female connectors. Switches any 8 lines. Silver plated switch contacts, gold plated connector contacts. Complete, nothing else to buy.



	each	3+
Pika-Switch # 2 (AB)	$79	$75
Pika-Switch # 5 (ABCDE)	$145	$135
Male Connector Option	No Charge	

TERMS: All Sales exclusively by mail/phone order. Cash, check, money order, MC, Visa. No COD. Add $4.50 shipping, NM residents add 4% tax. (Foreign customers: payment must be in U.S. funds drawn on a U.S. bank, add 10% for air shipment).

pika box

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1-800-547-4000

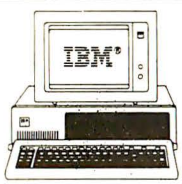
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Includes: Drives, Video Card, Perfect Software Package, MS-DOS, CP/M, Fast Graphics, BASIC, CP/M-86, Home Accountant and Communications Program.
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256K RAM Board with 64K **199.00**
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Diskmaster Floppy and Hard Disk Controller **225.00**
APPRATE IBM PROM Blaster **129.00**
CABLE for IBM Parallel Printer **29.95**
CABLE for Columbia MPC Parallel Printer **29.95**
CABLE for Eagle Parallel Printer **29.95**

Apple Compatible Products



AFDC-1 Floppy Disk Drive Controller **$69.95**
Runs DOS 3.3 with any standard Shugart compatible 5¼" disk drive. (2 drives each card). Does not read ½ track.

Apprate PROM Blaster **119.00**
"ALS" 80 Column Card **159.00**
"ALS" Z-CARD (Z80 CPU) **149.00**
API Apple Parallel Printer Interface card. Centronics Compatible **$45.00**

Software

WORD PROCESSOR (Benchmark)
For IBM or MS-DOS **$299.00**
MAILING LIST (Benchmark)
For Apple II **140.00**
For IBM or MS-DOS **140.00**
SPELLING CHECKER (Benchmark)
For IBM or MS-DOS **105.00**
TELECOM (Benchmark)
For IBM or MS-DOS **85.00**
CDEX IBM Training **52.00**
TALLGRASS (J format) **50.00**

General Products

	10 up	100 up
5¼" Diskettes		
SS/DD (100% certified)	1.75	1.55
DS/DD (100% certified)	2.50	2.30

BMC PRINTER

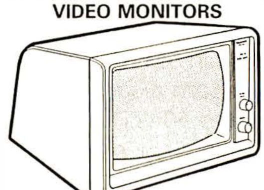


BX-80 dot matrix printer with 80 cps, 9 x 7 print head. Quiet, reliable and priced for entry level end-user **$259.00**

MODEM Novation 103 Smart-Cat .. **$210.00**

General Products- cont.

NEW MODEL SAMWOO DISPLAY VIDEO MONITORS



Features: • Anti glare screen • Attractive case • Std composite video input, also output for second monitor • 22 MHz video bandwidth • High resolution; 1,000 lines or 132 characters across • Adjustable contrast, brightness, V/H-hold, V-size, H-center • Input impedance: high or 75 ohm • Passes FCC test for computer equipment • UL approved
Compatible With: IBM, IBM PCjr, Apple II, Applelle, Comodore, Columbia MPC, Eagle, Radio Shack, Sinclair/Timex, and more.

	Each	3-up
DM-216 12" Green	$145.00	Call
DM-216 12" Orange	$149.00	Call

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EPROM & RAM SUPER SALE

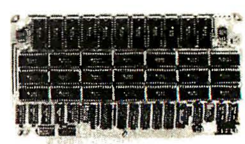
P/N	Description	8-24	25up
2716	(450nS)	3.95	3.95
2732	(450nS)	4.40	4.40
2764	(28 pin)	8.95	Call
4164	(in stock)	Call	Call
6116P-3	(150nS)	6.10	Call

Mother Boards & Card Cages

SLOTS	Bare Bd	KIT	A & T	w/CAGE
6	$19.00	$44.00	$59.00	$84.00
8	24.00	56.00	81.00	116.00
12	29.00	75.00	110.00	150.00

10MHz. No termination. Includes power indicator and wiring for muffin fan. Uses OK connector for solderless installation and removal of power & reset lines.

S-100 Products



64KSM A&T without RAM ... **$155.00**
64KSM A&T w/64k RAM (32-6116's). **339.00**
S-100 Board Uses 6MHz 6116's. ½ Amp max. power, Bank Select plus Extended Addressing allows for multi-memory board set-up. 4 independant 16K Blocks make easy use with multi-user systems. Any 2K RAM may be replaced by a 2716 EPROM.

SBC-880 Z80A CPU, A&T **$169.00**
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4MHz Z80A CPU boards with Serial/Parallel Ports.

UFDC-1 Floppy Controller, A&T **245.00**
UFDC-1 Floppy Controller, Kit **225.00**
The UFDC-1 Floppy Controller uses the WD1795 chip which runs either and/or 8"/5¼" Disk Drives.

CLOCK CALENDAR A&T **115.00**
CLOCK CALENDAR Kit **95.00**
This S-100 Clock Calendar Board has 4 interrupts, Time, Day of Week and Battery Backup.

Special Sale Items

Apple Keyboard Assm & Tested .. **$49.95**
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ANCHOR MARK VI (IBM PC)	199.95
ANCHOR MARK VII (RS-232)	109.95
ANCHOR MARK X11 (RS-232)	279.95
ANCHOR VOLKSMODEM	64.95
NOVATION J-CAT	104.95
NOVATION 212 AUTO CAT	579.95
SMARTCAT 212 (1200 BAUD)	429.95
SMARTMODEM 300 BAUD	194.95
SMARTMODEM 1200 BAUD	484.95
SMARTMODEM 1200B - IBM	449.95
US ROBOTICS AUTODIAL 212	449.95
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EPSON FX-100 F/T	LOW!!
EPSON MX-100 F/T	LOW!!
EPSON RX-80	LOW!!
EPSON RX-80 F/T	LOW!!
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OKIDATA PACEMARK 2410S	LOW!!
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OKIDATA 83A W/OKIGRAPH	LOW!!
OKIDATA 84P	LOW!!
OKIDATA 84S	LOW!!
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COMPUTERS

APPLE IIe STARTER SYSTEM	LOW!!
APPLE MACINTOSH COMPUTER	LOW!!
COMMODORE 64 COMPUTER	LOW!!
COMMODORE 1541 DISK DRIVE	LOW!!
COLUMBIA VP PORTABLE	LOW!!
COLUMBIA 1600-1 COMPUTER	LOW!!

IBM-PC COMPATIBLE SYSTEM
128K, 2-DS/DD DRIVES, KEYBOARD
WITH COMPLETE SOFTWARE PACKAGE

EAGLE PC PLUS-2 SYSTEM	3199.95

128K, 2-DS/DD DRIVES,
MONITOR, EAGLEWRITER, MS-DOS,
EAGLECALC, & CP/M-86

EAGLE SPIRIT-II	2549.95
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PORTABLE 128K EXPANDABLE TO
640K ON BOARD, 1 320K FLOPPY,
10 MEGABYTE HARD DISK, IBM
COMPATABLE KEYBOARD, 2 SERIAL
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MONOCHROME MONITOR, CP/M 86

NEC APC-H01	2049.95
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SANYO 555 COMPUTER	1049.95
TELEVIDEO TPC-1	LOW!!

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APPLE II COMPATABLE SYSTEM
64K, DETACHABLE KEYBOARD,
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HI-RES 12" GREEN MONITOR,
RBG & COMPOSITE COLOR OUTPUT,
2 CPU'S (Z-80 A & 6502),
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ZORBA PORTABLE COMPUTER	1399.95

BUILT IN 7" GREEN SCREEN,
2 DS/DD DISK DRIVES, RS-232,
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EMULATION MODE FOR OSBORNE I,
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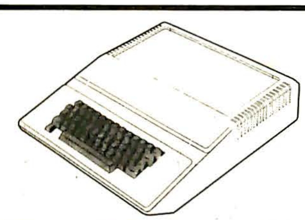
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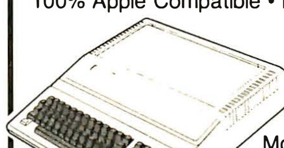
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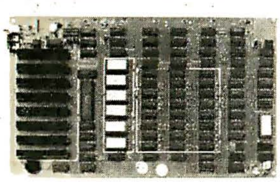
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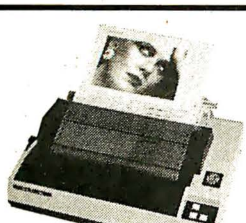


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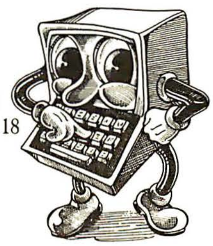
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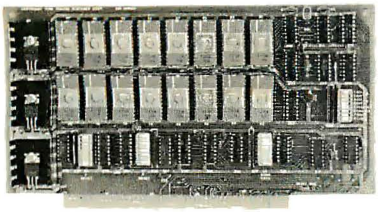
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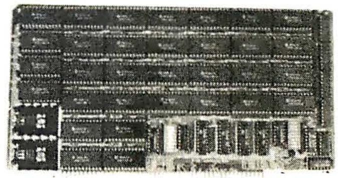
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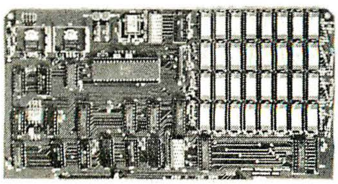
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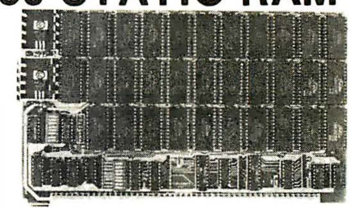
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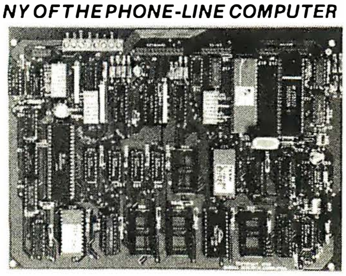
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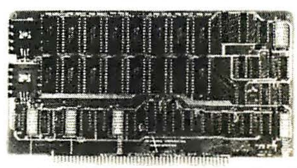
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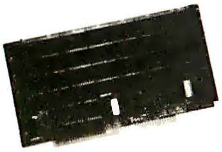
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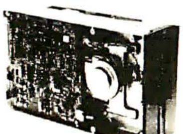
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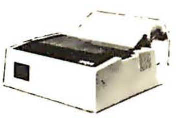
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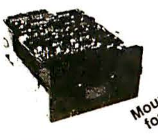
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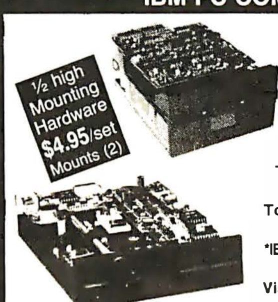
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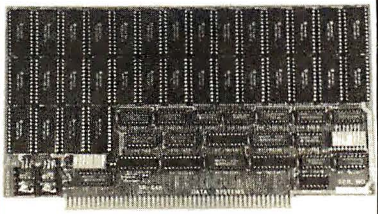
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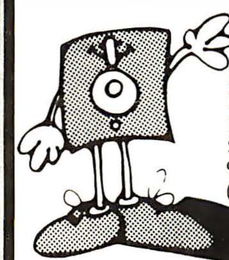
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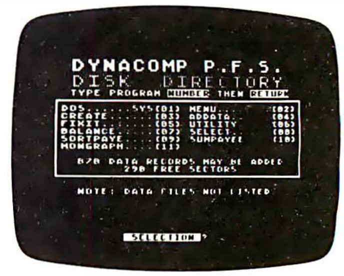
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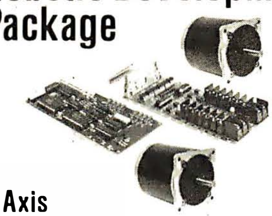
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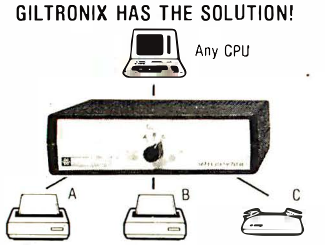
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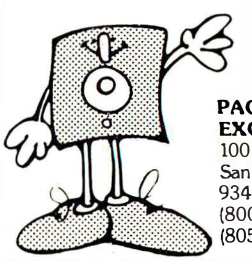
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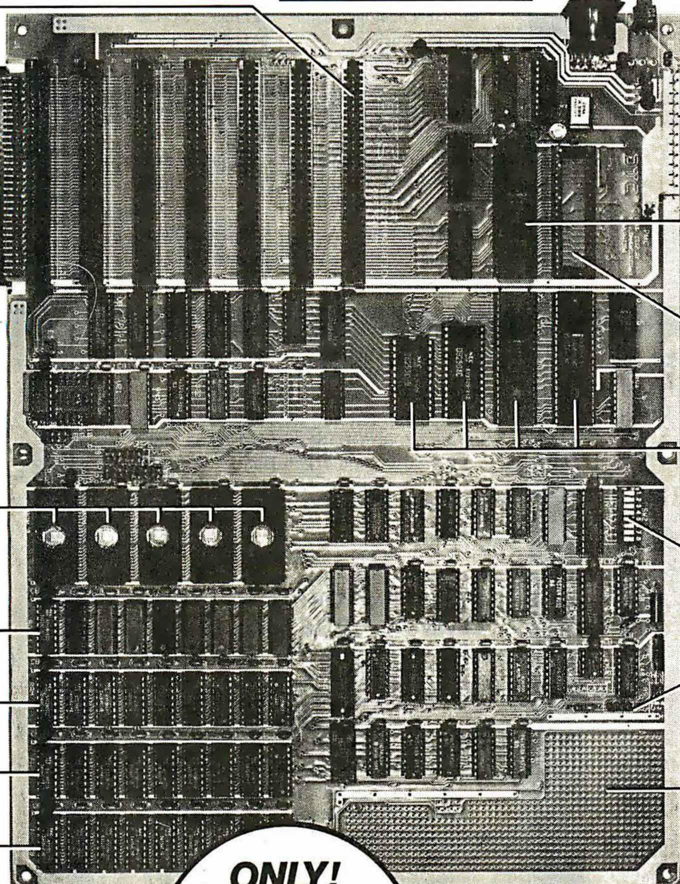
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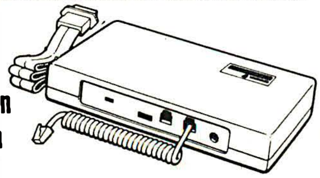
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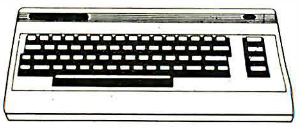
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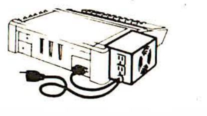
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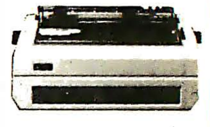


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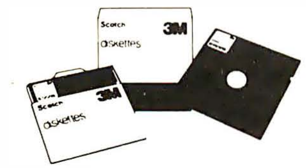
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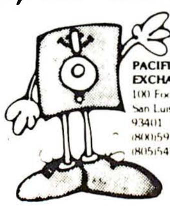
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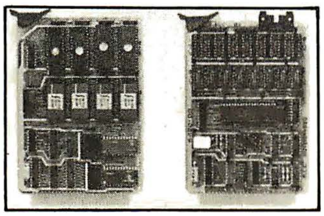
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```
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HL=HL+DE;                  DAD   D
IF A-L EQUAL               CMP   L
    THEN                   JNZ   L1
        A=A-14             SUI   14
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        A=L;            L1:MOV   A,L
M(BC)=A;                L2:STAX  B
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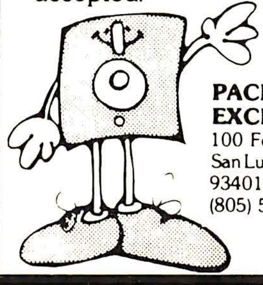
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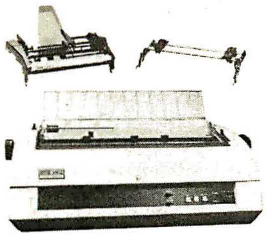
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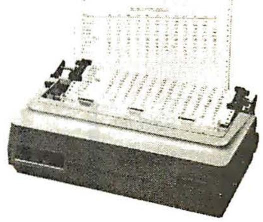
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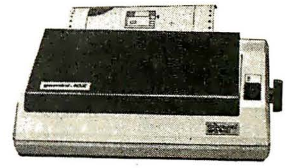
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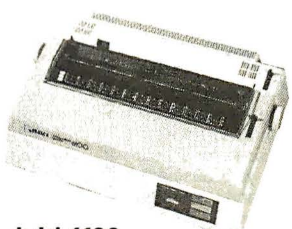
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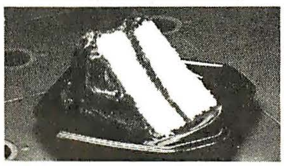
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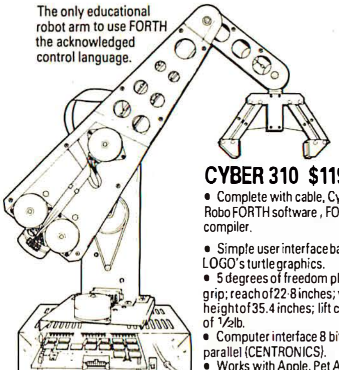
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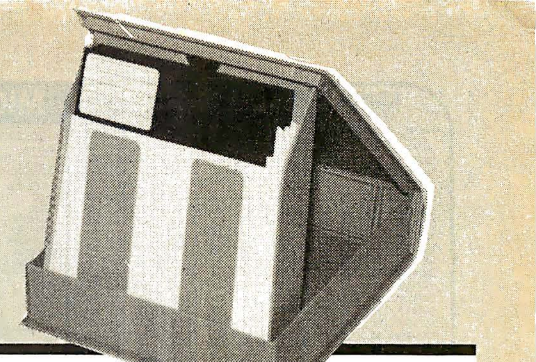
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NEW! MICROMODEM IIe—Hayes

The standard in direct-connect, plug-in-modem cards for Apple, 110-300 baud. Includes FREE Smartcom I

Micromodem IIe *List Price 299.95* **$239.95**

KOALA PAD—Koala Tech.

A touch sensitive pad that functions like a joystick or mouse, allowing you to move the cursor around the screen with the touch of a finger. Complete with software

Koala Pad *List Price 124.95* **$99.95**

16K RAM CARD For APPLE II

Expand your Apple II to 64K, use as language card, full one year warranty. Why spend $175.00?

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The ultimate parallel printer graphics interface card with many new features, now at a new low price!

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80 column x 24 line video card for Apple II addressable 25th status line, normal/inverse or high/low video, 128 ASCII characters, upper and lower case, 7 x 9 dot matrix with true descenders, CP/M, Pascal and Fortran compatible, 40/80 column selection from keyboard, 2 year warranty. Best 80 column card!

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Two serial I/O ports plus two parallel I/O ports

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Silent, simple and on SALE! A better motherboard

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18 Slot Bare board *List Price 70.00* **$54.95**
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4 MHz Z-80A CPU with serial and parallel I/O

A & T *List Price 350.00* **$299.95**

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High reliability, double density disk controller

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2 or 4 MHz switchable Z-80 CPU board with serial I/O

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Hayes®

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1200 BAUD SMART CAT Novation

103/212 Smart Cat and 103 Smart Cat, 1200 and 300 baud, built-in dialer, auto re-dial if busy, auto answer/disconnect, direct connect, LED readout displays mode analog/digital loopback self tests, usable with multi-line phones

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J-CAT MODEM—Novation

1/5 the size of ordinary modems, Bell 103, manual or, auto-answer, automatic answer/orginate, direct connect, built-in self-test, two LEDs and audio beeps provide status information

Novation J-Cat *List Price 149.00* **$114.95**

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Computer Products

Circle 193 on inquiry card.

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7400

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SN7402N	14	.25
SN7403N	14	.25
SN7404N	14	.25
SN7405N	14	.25
SN7406N	14	.45
SN7407N	14	.29
SN7408N	14	.25
SN7409N	14	.25
SN7410N	14	.25
SN7411N	14	.25
SN7412N	14	.49
SN7413N	14	.39
SN7414N	14	.49
SN7416N	14	.25
SN7417N	14	.25
SN7420N	14	.19
SN7421N	14	.49
SN7422N	14	.49
SN7423N	16	.59
SN7425N	14	.29
SN7426N	14	.29
SN7427N	14	.25
SN7428N	14	.59
SN7430N	14	.25
SN7432N	14	.29
SN7437N	14	.25
SN7438N	14	.29
SN7439N	14	.59
SN7440N	14	.19
SN7441N	16	.89
SN7442N	16	.45
SN7443N	16	1.25
SN7444N	16	1.25
SN7445N	16	.69
SN7446N	16	.69
SN7447N	16	.69
SN7448N	16	.69
SN7450N	14	.19
SN7451N	14	.19
SN7453N	14	.19
SN7454N	14	.19
SN7459N	14	.25
SN7460N	14	.39
SN7470N	14	.29

Part No.	**Pins	Price
SN7472N	14	.29
SN7473N	14	.35
SN7474N	14	.35
SN7475N	16	.45
SN7476N	16	.35
SN7479N	14	4.95
SN7480N	14	.89
SN7482N	14	1.49
SN7483N	16	.59
SN7485N	16	59
SN7486N	14	.35
SN7489N	16	2.25
SN7490N	14	.39
SN7491N	14	.79
SN7492N	14	.39
SN7493N	14	.39
SN7494N	14	.89
SN7495N	14	.49
SN7496N	16	.49
SN7497N	16	3.25
SN74100N	24	1.95
SN74104N	14	1.19
SN74105N	14	1.19
SN74107N	14	.29
SN74109N	16	.39
SN74116N	24	1.49
SN74121N	14	.39
SN74122N	14	.69
SN74123N	16	.49
SN74125N	14	.45
SN74126N	14	.45
SN74132N	14	.49
SN74136N	14	.69
SN74141N	16	.89
SN74142N	16	3.95
SN74143N	24	3.95
SN74144N	24	3.95
SN74145N	16	.59
SN74147N	16	1.49
SN74148N	16	1.19
SN74150N	24	1.19
SN74151N	16	.59
SN74152N	14	.59
SN74153N	16	.59
SN74154N	24	1.25
SN74155N	16	.59

Part No.	**Pins	Price
SN74156N	16	.59
SN74157N	16	.59
SN74160N	16	.69
SN74161N	16	.69
SN74162N	16	.69
SN74163N	16	.69
SN74164N	14	.69
SN74165N	16	.69
SN74166N	16	.89
SN74167N	16	2.95
SN74170N	16	1.29
SN74172N	24	4.95
SN74173N	16	.69
SN74174N	16	.69
SN74175N	16	.69
SN74176N	14	.69
SN74177N	14	.69
SN74179N	16	1.49
SN74180N	14	.69
SN74181N	24	1.95
SN74182N	16	1.19
SN74184N	16	2.49
SN74185N	16	2.49
SN74190N	16	.69
SN74191N	16	.69
SN74192N	16	.69
SN74193N	16	.69
SN74194N	16	.69
SN74195N	16	.69
SN74196N	14	.89
SN74197N	14	.89
SN74198N	24	1.19
SN74199N	24	1.19
SN74221N	16	1.19
SN74251N	16	.79
SN74276N	20	2.49
SN74279N	16	.79
SN74283N	16	1.49
SN74284N	16	2.95
SN74285N	16	2.95
SN74365N	16	.55
SN74366N	16	.55
SN74367N	16	.55
SN74368N	16	.55
SN74390N	16	1.49
SN74393N	14	1.49

74LS

74LS00	14	.25
74LS01	14	.25
74LS02	14	.29
74LS03	14	.25
74LS04	14	35
74LS05	14	29
74LS08	14	.29
74LS09	14	.29
74LS10	14	.29
74LS11	14	.35
74LS12	14	.35
74LS13	14	.39
74LS14	14	.59
74LS15	14	.35
74LS20	14	.29
74LS21	14	.29
74LS22	14	.29
74LS26	14	.29
74LS27	14	.29
74LS28	14	.35
74LS30	14	.29
74LS32	14	.39
74LS33	14	.55
74LS37	14	.35
74LS38	14	35
74LS40	14	.29
74LS42	16	.55
74LS47	16	.75
74LS48	16	.75
74LS49	14	75
74LS51	14	.25
74LS54	14	.25
74LS55	14	.29
74LS73	14	.39
74LS74	14	.49
74LS75	16	.39
74LS76	16	.39
74LS78	14	.39
74LS83	16	.65
74LS85	16	.89
74LS86	14	.39
74LS90	14	.55

74LS92	14	.55
74LS93	14	.55
74LS95	14	.79
74LS96	16	.89
74LS107	14	.39
74LS109	16	.39
74LS112	16	.39
74LS113	14	.39
74LS114	14	.39
74LS122	14	.49
74LS123	16	.89
74LS125	14	59
74LS126	14	.49
74LS132	14	.59
74LS133	16	.59
74LS136	14	.39
74LS138	16	.89
74LS139	16	.79
74LS151	16	.59
74LS153	16	.59
74LS154	24	1.29
74LS155	16	69
74LS156	16	.69
74LS157	16	.69
74LS158	16	.59
74LS160	16	.69
74LS161	16	.69
74LS162	16	69
74LS163	16	.69
74LS164	14	.69
74LS165	16	1.19
74LS168	16	1.19
74LS169	16	1.19
74LS170	16	1.49
74LS173	16	.69
74LS174	16	.69
74LS175	16	.69
74LS181	24	2.95
74LS190	16	.89
74LS191	16	.89

74LS192	16	.79
74LS193	16	.79
74LS194	16	.69
74LS195	16	.69
74LS197	14	.79
74LS221	16	.89
74LS240	20	1.09
74LS241	20	1.09
74LS242	14	1.09
74LS243	14	1.09
74LS244	20	1.49
74LS245	20	1.49
74LS247	16	1.09
74LS248	16	1.09
74LS249	16	1.09
74LS251	16	.59
74LS253	16	.59
74LS257	16	.59
74LS258	16	.59
74LS260	14	.59
74LS266	14	.69
74LS273	20	1.49
74LS279	16	.49
74LS283	16	.69
74LS290	14	.89
74LS293	14	.79
74LS298	16	.89
74LS352	16	1.29
74LS353	16	1.29
74LS365	16	.49
74LS366	16	.49
74LS367	16	.49
74LS368	16	.49
74LS373	20	1.49
74LS374	20	1.49
74LS375	16	.69
74LS386	14	.45
74LS393	14	1.19
74LS399	16	1.49
74LS670	16	1.49
81LS95	20	1.49
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74S00	14	.35
74S02	14	.35
74S03	14	.35
74S04	14	.45
74S05	14	.45
74S08	14	.39
74S09	14	.39
74S10	14	.35
74S11	14	.35
74S15	14	.35
74S20	14	35
74S22	14	.35
74S30	14	.35
74S32	14	.45
74S38	14	.89
74S40	14	39
74S51	14	.35
74S64	14	.39
74S65	14	.39
74S74	14	.55
74S85	16	2.49
74S86	14	.55
74S112	16	.55
74S113	14	.55

74S114	14	.55
74S133	16	.45
74S134	16	.50
74S135	16	.69
74S136	14	1.39
74S138	16	.89
74S139	16	.89
74S140	14	.55
74S151	16	.99
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74S175	16	1.19
74S188*	16	1.49
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74S240	20	2.25
74S241	20	2.25
74S242	14	2.49

74S243	14	2.49
74S244	20	2.49
74S251	16	1.19
74S253	16	1.19
74S257	16	1.19
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CD4050	16	.39
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CD4052	16	.99
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CD4512	16	1.19
CD4514	24	2.49
CD4515	24	2.49
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CD4519	16	.59
CD4520	16	1.19
CD4526	16	1.49
CD4528	16	1.49
CD4529	16	1.69
CD4543	16	1.95
CD4562	14	6.95
CD4566	16	1.39
CD4583	16	2.49
CD4584	14	.69
CD4723	16	1.19
CD4724	16	1.19
MC14409	16	13.95
MC14410	16	13.95
MC14411	24	11.95
MC14412	16	13.95
MC14419	16	7.95
MC14433	24	13.95
MC14538	16	1.19
MC14541	14	1.19

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MICROPROCESSOR CHIPS

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MCS6502B	40	MPUw/Clock al 3MHz	9.95
6809	40	CPU—8-bit (Internal Clock) 1MHz	14.95
6809E	40	CPU—8-bit (External Clock) 1MHz	14.95
INS8035N-6	40	MPU—8-bit (6MHz)	5.95
INS8039N	40	CPU-Sgl.chip 8-bit (128bts. Ram)	5.95
INS8040N-6	40	CPU (256 bytes RAM)	9.95
INS8070N	40	CPU(64 bytesRAM)	29.95
INS8073N	40	CPUw/BasicMicro Interpreter	29.95
P8085A	40	CPU	4.95
8086	40	CPU 16-bit 5MHz	24.95
8088	40	CPU 8/16-bit	29.95
8155	40	HMOSRAM I/O Port-Timer	6.95
8748	40	HMOS EPROM MPU	24.95

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Z80-DMA	40	Direct Memory Access Circuit	9.95
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Z80-SIO/9	40	Serial I/O	12.95
Z80A	40	CPU(MK3880N-4)(780C-1) 4MHz	4.49
Z80A-CTC	28	Counter Timer Circuit	4.95
Z80A-DART	40	Dual Asynchronous Rec./Trans.	9.95
Z80A-DMA	40	Direct Memory Access Circuit	12.95
Z80A-PIO	40	Parallel I/O Interface Controller	3.95
Z80A-SIO/0	40	Serial I/O (TxCB and RxCB bonded)	12.95
Z80A-SIO/1	40	Serial I/O (Lacks DTRB)	12.95
Z80A-SIO/2	40	Serial I/O (Lacks SYNCB)	12.95
Z80A-SIO/9	40	Serial I/O	12.95
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Z80B-CTC	28	Counter Timer Circuit	12.95
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Z80B-PIO	40	Parallel I/O Interface Controller	12.95
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Z8030	40	Serial Comm. Controller	44.95
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MC6828	24	Priority Interrupt Controller	15.95
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INS8080A	40	CPU	2.95
INS8154	40	128 Byte RAM 16-Bit I/O	13.95
8156	40	RAM with I/O Port and Timer	6.95
INS82C06	20	Octal D Flip Flop Tri-State (74C374)	2.49
DP8212	24	8-bit Input/Output (74S412)	2.25
DP8214	24	Priority Interrupt Control	2.95
DP8216	16	Bi-Directional Bus Driver	1.95
DP8224	16	Clock Generator/Driver	2.25
DP8226	16	Bus Driver	2.25
DP8228	28	System Cont./Bus Driver (74S428)	3.49
DP8238	28	System Controller (74S438)	4.49
INS8243	24	I/O Expander for 48 Series	3.95
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INS8250N	40	Asyn. Comm. Element	10.95
DP8251	28	Prog. Comm. I/O (USART)	4.49
DP8253	24	Prog. Interval Timer	6.95
DP8255	40	Prog. Peripheral I/O (PPI)	4.49
DP8257	40	Prog. DMA Control	5.95
DP8259	28	Prog. Interrupt Control	6.95
DP8275	40	Prog. CRT Controller	29.95
DP8279	40	Prog. Keyboard/Display Interface	8.95
DP8303	20	8-Bit Tri-State Bi-Directional Trans.	3.95
DP8304	20	8-bit Bi-Directional Receiver	2.95
DP8307	20	8-bit Bi-Directional Receiver	2.95
DP8308	20	8-bit Bi-Directional Receiver	2.95
DP8310	20	Octal Latched Peripheral Driver	4.95
8741	40	8-bit Univ. Peripheral Interface	29.95
8755	40	16K EPROM with I/O	24.95

DISK CONTROLLERS

INS1771-1	40	Single Density	16.95
FD1791	40	Single/Dual Density (Inv.)	29.95
FD1793	40	Single/Double Density (True)	29.95
FD1795	40	Dual Density/Side Select (Inv.)	29.95
FD1797	40	Dual Density/Side Select True	29.95
6843P	40	Floppy Disk Controller (1MHz)	29.95

SPECIAL FUNCTION

DS0025CN	8	Dual MOS Clock Driver (5MZ)	2.49
DS0026CN	8	Dual MOS Clock Driver (5MZ)	1.95
INS2651	28	Communication Chip	8.95
MC3470P	18	Floppy Disk Read Amp System	4.95
MM58167AN	24	Microprocessor Real Time Clock	8.95
MM58174AN	16	Micro. Compatible Time Clock	7.95
COP402N	40	Microcontroller w/64-digit RAM and Direct LED Drive	5.95
COP402MN	40	Microprocessor w/64-digit RAM & Direct LED Drive w/N Buss Int.	5.95
COP470N	20	32-seg VAC Fluor. Drvr. (20-pin pkg.)	3.25
MM5369AA/N	8	Prog. Oscillator/Divider (60Hz)	1.79
MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.95

DYNAMIC RAMS

Part No.	**Pins			Price
1103	18	1024x1	(300ns)	.99
4027	16	4096x1	(250ns)	2.49
4116N-2	16	16,384x1	(150ns)	1.89 - 8/14.95
4116N-3	16	16,384x1	(200ns)	1.69 - 8/12.95
4116N-4	16	16,384x1	(250ns)	1.49 - 8/10.95
4164N-150	16	65,536x1	(150ns)	6.95 - 8/49.95
4164N-200	16	65,536x1	(200ns)	5.95 - 8/44.95
MM5261	18	1024x1	(300ns)	.49 - 8/1.95
MM5262	22	2048x1	(365ns)	.49 - 8/1.95
MM5270	18	4096x1	(250ns) MK4096	4.95
MM5280	22	4096x1	(200ns) 2107	3.95
MM5290-2	16	16,384x1	(150ns)	1.89 - 8/14.95
MM5290-3	16	16,384x1	(200ns)	1.69 - 8/12.95
MM5290-4	16	16,384x1	(250ns)	1.49 - 8/10.95
MM5298-3	16	8192x1	(200ns)	1.69

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1101	16	256x1	(650ns)	1.49
2101	22	256x4	(450ns) 8101	2.49
2102	16	1024x1	(350ns)	.89
21L02	16	1024x1	(450ns) L.P.	1.49
2111	18	256x4	(450ns) 8111	2.95
2112	18	256x4	(450ns) MOS	1.95
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2114L	18	1024x4	(450ns) L.P.	1.95 - 8/13.95
2114-2	18	1024x4	(200ns)	1.75 - 8/11.95
2114L-2	18	1024x4	(200ns) L.P.	2.25 - 8/14.95
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2148	18	1024x4	(70ns)	4.95
TMS4045	18	1024x4	(450ns)	3.95
TMS40L47-45	20	1024x4	(450ns)	2.95
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MM5257	18	4096x1	(450ns) 4044	4.95
HM6116P-3	24	2048x8	(150ns) CMOS	5.95
HM6116-4	24	2048x8	(200ns) CMOS	4.95
HM6116LP-4	24	2048x8	(200ns) L.P. CMOS	5.49
HM6264P-15	28	8192x8	(150ns) CMOS	39.95
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74C920	22	256x4	(250ns)	3.95
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74S200	16	256x1	(80ns) 93410	3.95
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74S289	16	16x4	(35ns) 3101	2.25
82S10	16	1024x1	(50ns) O.C. (93415)	3.95
82S25	16	16x4	(50ns) O.C. (74S289)	2.25

PROMS/EPROMS

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2708	24	1024x8	(450ns)	3.95
2708-5	24	1024x8	(550ns) SM00246	2.95
TMS2516	24	2048x8	(450ns) 2716	5.95
TMS2532	24	4096x8	(450ns) NMC2532	6.95
TMS2564	28	8192x8	(450ns)	14.95
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2716	24	2048x8	(450ns)	4.95
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2716D-5	24	2048x8	(550ns)	4.49
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2732A-3	24	4096x8	(300ns)	7.95
2732A-4	24	4096x8	(450ns) 21V	6.95
2732D-4	24	4096x8	(550ns)	5.95
2758D-A	24	1024x8	(450ns)	2.95
2764-4	28	8192x8	(450ns)	9.95
2764-3	28	8192x8	(300ns)	14.95
MM5204D	24	512x8	(1us)	4.95
MCM68764	24	8192x8	(450ns)	24.95
27128	28	16,384x8	(450ns) 128K EPROM	59.95
74S188	16	32x8	PROM O.C. (6330-1)	1.49
74S287	16	256x4	PROM T.S. (6301-1)	1.95
74S288	16	32x8	PROM T.S. (6331-1)	1.95
74S387	16	256x4	PROM O.C. (6300-1)	1.95
74S471	20	256x8	PROM T.S. (6309-1)	5.95
74S472	20	512x8	PROM T.S. (6349-1)	4.95
74S473	20	512x8	PROM O.C. (6348)	4.95
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74S475	24	512x8	PROM O.C. (6340)	4.95
74S476	18	1024x4	PROM T.S.	6.95
74S478	24	1024x8	PROM T.S.	8.95
74S570	16	512x4	PROM O.C. (6305)	2.95
74S571	16	512x4	PROM T.S. (6306)	2.95
74S572	18	1024x4	PROM O.C. (6352)	4.95
74S573	18	1024x4	PROM T.S. (82S137)	4.95
82S23	16	32x8	PROM O.C. (27S18)	2.95
82S115	24	512x8	PROM T.S. (27S15)	9.95
82S123	16	32x8	PROM T.S. (27S19)	2.95
82S126	16	256x4	PROM O.C. (27S20)	2.95
82S129	16	256x4	PROM T.S. (27S21)	2.95
82S130	16	512x4	PROM O.C. (27S12)	3.95
82S185	18	2048x4	PROM T.S. (TBP24S81)	9.95
82S190	24	2048x8	(80ns)	14.95
82S191	24	2048x8	(80ns)	14.95
DM87S180N	24	1024x8	PROM O.C. (82S180)	9.95
DM87S181N	24	1024x8	PROM T.S. (82S181)	9.95
DM87S184N	18	2048x4	PROM O.C. (82S184)	9.95
DM87S185N	18	2048x4	PROM T.S. (82S185)	9.95
DM87S190N	24	2048x4	PROM O.C. (82S190)	14.95
DM87S191N	24	2048x8	PROM T.S. (82S191)	14.95

DATA ACQUISITION

DC10		Mostek DC/DC Convert. +5V to -9V	2.95
MC3470P	18	Floppy Disk Read AMP System	4.95
MC1408L7	16	7-bit D/A Converter (DAC0807LCN)	1.49
MC1408L8	18	8-bit D/A Converter (DAC0808LCN)	2.25
ADC0803LCN	20	8-bit A/D Converter (±1/2LSB)	4.95
ADC0804	20	8-bit A/D Converter (1LSB)	3.49
DAC0806	16	8-bit D/A Converter (0.78% Lin.)	1.95
ADC0809	28	8-bit A/D Converter (8-Ch. Multi.)	4.49
ADC0817	40	8-bit A/D Converter (16-Ch. Multi.)	9.95
DAC1000	24	10-bit D/A Conv. Micro. Comp. (0.05%)	7.95
DAC1008	20	10-bit D/A Conv. Micro. Comp. (0.20%)	6.95
DAC1020	16	10-bit D/A Conv. (0.05% Lin.)	7.95
DAC1022	16	10-bit D/A Conv. (0.20% Lin.)	5.95
DAC1222	18	12-bit D/A Conv. (0.20% Lin.)	6.95
LM334Z		Constant Current Source	1.19
LM335Z		Temperature Transducer	1.40
LM399H		Temp. Comp. Prec. Ref. (.5ppm/C°)	5.00
AY-5-1013A	40	30K Baud Uart (TR1602)	3.95

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	1-9	10-99	100-up
8 pin LP	.16	.14	.13
14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.16
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.25
22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
36 pin LP	.46	.42	.39
40 pin LP	.49	.46	.43

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14 pin SG	.43	.39	.37
16 pin SG	.47	.43	.41
18 pin SG	.53	.49	.47
24 pin SG	.69	.65	.61
28 pin SG	.81	.76	.72
36 pin SG	1.09	1.03	.97
40 pin SG	1.21	1.14	1.08

LP

SG

ST

WW

SOLDERTAIL STANDARD (TIN)

	1-9	10-99	100-up
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16 pin ST	.34	.32	.30
18 pin ST	.38	.36	.34
20 pin ST	.45	.43	.41
24 pin ST	.49	.46	.43
28 pin ST	.69	.67	.63
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16 pin WW	.69	.65	.61
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20 pin WW	1.09	1.05	.99
22 pin WW	1.25	1.19	1.15
24 pin WW	1.29	1.23	1.18
28 pin WW	1.59	1.50	1.45
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Digitalker™

DT1050 — Applications: Teaching aids, appliances, clocks, automotive, telecommunications, language translations, etc.

The DT1050 is a standard DIGITALKER kit encoded with 137 separate and useful words, 2 tones, and 5 different silence durations. The words and tones have been assigned discrete addresses, making it possible to output single words or words concatenated into phrases or even sentences. The "voice" output of the DT1050 is a highly intelligible male voice. Female and children's voices can be synthesized. The vocabulary is chosen so that it is applicable to many products and markets.

The DT1050 consists of a Speech Processor Chip, MM54104 (40-pin) and two (2) Speech ROMs MM52164SSR1 and MM52164SSR2 (24-pin) along with a Master Word list and a recommended schematic diagram on the application sheet.

DT1050 Digitalker™ .... $34.95 ea.
MM54104 Processor Chip .... $14.95 ea.

DT1057 - Expands the DT1050 vocabulary from 137 to over 260 words. Includes 2 ROMs and specs.
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INTERSIL

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7106CPL	40	3½ Digit A/D (LCD Drive)	9.95
FE0203D	-	3½ Digit LCD Display for 7106 & 7116	19.95
7106EV/Kit*	40	IC, Circuit Board, Display	34.95
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7107EV/Kit*	40	IC, Circuit Board, Display	29.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD.	16.95
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7205IPG	24	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	24	Stopwatch Chip, XTL	14.95
7206CJPE	16	Tone Generator	4.95
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7216CIJI	28	8 Digit Freq. Counter C.A.	24.95
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7217AIPI	28	4 Digit LED Up/Down Counter C.C.	11.95
7224IPL	40	LCD 4½ Digit Up Counter DRI	10.95
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30009 1983 INTERSIL Data Book (1356p.) **$9.95**

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74HC02	14	.59
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74HCU04	14	.65
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74HC10	14	.59
74HC11	14	.59
74HC14	14	.85
74HC20	14	.59
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74HC32	14	.75
74HC42	16	.99
74HC51	14	.75
74HC58	14	.75
74HC73	14	.79
74HC74	14	.79
74HC75	16	.89
74HC76	16	.79
74HC85	16	1.59
74HC86	14	.69
74HC107	14	.79
74HC109	16	.79
74HC112	16	.79
74HC113	14	.79
74HC132	14	.99
74HC137	16	1.95
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74HC151	16	.89
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74HC154	24	2.49
74HC157	16	.89
74HC158	16	.89
74HC160	16	1.29
74HC161	16	1.29
74HC162	16	1.29
74HC163	16	1.29
74HC164	14	1.29
74HC165	16	2.79
74HC173	16	1.69
74HC174	16	.99
74HC175	16	.99
74HC192	16	1.39
74HC193	16	1.39
74HC194	16	1.09
74HC195	16	1.09
74HC237	16	2.95
74HC240	20	1.95
74HC241	20	1.95
74HC242	14	1.95
74HC243	14	1.95
74HC244	20	1.95
74HC245	20	2.49

74HC251	16	.89
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74HC257	16	.89
74HC259	16	1.49
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74HC280	14	3.95
74HC373	20	2.39
74HC374	20	2.39
74HC390	16	1.49
74HC393	14	1.49
74HC533	20	2.39
74HC534	20	2.39
74HC595	16	3.95
74HC688	20	3.19
74HC4002	14	.59
74HC4017	16	2.19
74HC4020	16	1.39
74HC4024	14	1.59
74HC4040	16	1.39
74HC4060	16	1.39
74HC4075	14	.59
74HC4078	14	.69
74HC4511	16	2.69
74HC4514	24	3.79
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PAL14L4	20	Quad 14-Input AND-OR-Invert Gate Array (Low Output)	3.95
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30012 1982 NATIONAL PAL Data Book (176p.) .. **$5.95**

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74C14	14	.69
74C20	14	.35
74C30	14	.35
74C32	14	.39
74C42	16	1.39
74C48	16	1.95
74C73	14	.79
74C74	14	.69
74C85	16	1.95
74C86	14	.39
74C89	16	5.95
74C90	14	1.19
74C93	14	1.19

74C95	14	1.39
74C107	14	.89
74C151	16	2.49
74C154	24	3.49
74C157	16	2.25
74C160	16	1.19
74C161	16	1.19
74C162	16	1.19
74C163	16	1.19
74C164	14	1.49
74C173	16	1.19
74C174	16	1.19
74C175	16	1.19
74C192	16	1.49
74C193	16	1.69
74C195	16	1.39

74C221	16	1.95
74C240	20	1.95
74C244	20	1.95
74C373	20	2.49
74C374	20	2.49
74C901	14	.59
74C903	14	.59
74C906	14	.59
74C911	28	8.95
74C912	28	8.95
74C915	18	1.19
74C917	28	8.95
74C922	18	4.49
74C923	20	4.95
74C925	16	5.95
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TL084CN	14	1.95
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LM302H		1.95
LM304H		1.95
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LM307CN	8	.45
LM308CN	8	.69
LM309K		1.25
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LM311CN	8	.69
LM312H		2.49
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LM317K		3.95
LM318CN	8	1.95
LM319N	14	1.95
LM320K-5		1.35
LM320K-12		1.35
LM320K-15		1.35
LM320T-5		.89
LM320T-12		.89
LM320T-15		.89
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LM324N	14	.59
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LM339N	14	.69
LM340K-5		1.35
LM340K-12		1.35
LM340K-15		1.35

LM340T-5		.79
LM340T-12		.79
LM340T-15		.79
LF347N	14	1.49
LM348N	14	99
LM350K		4.95
LF355N	8	1.10
LF356N	8	1.10
LM370N	14	4.49
LM373N	14	3.95
LM377N	14	1.95
LM380N	14	.89
LM381N	14	1.79
LM382N	14	1.39
LM384N	14	1.79
LM386N-3	8	.89
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NE531V	8	2.95
NE544N	14	2.95
NE550A	14	1.95
NE555V	8	.35
LM556N	14	.69
NE564N	16	2.95
LM565N	14	1.19
LM566CN	8	1.49
LM567V	8	.99
NE570N	16	3.95
LM703CN	8	1.19
LM709N	14	.49
LM710N	14	.69
LM711N	14	.79

LM723N	14	.55
LM733N	14	1.00
LM739N	14	1.95
LM741CN	8	.35
LM747N	14	.69
LM748N	8	.59
LM1310N	14	1.49
LM1458CN	8	.59
LM1488N	14	.89
LM1489N	14	.89
LM1496N	14	1.95
LM1800N	16	2.49
LM1871N	18	2.95
LM1872N	18	3.25
LM1877N-9	14	2.49
LM1889N	16	2.25
LM1896N	14	2.95
LM2002T		1.95
LM3189N	16	1.59
LM3900N	14	.59
LM3905CN	8	1.19
LM3909N	8	.99
LM3914N	18	2.95
LM3915N	18	2.95
LM3916N	18	2.95
RC4136N	14	1.25
RC4151NB	8	1.95
RC4194TK		4.49
NE5532	8	2.49
NE5534	8	1.69
ICL8038B	14	3.95
LM13080N	8	1.19
LM13600N	16	1.19

MORE AVAILABLE

30003 1982 Nat. Linear Data Book (1952 pgs.) . **$11.95**

Circle 194 on inquiry card.

Circle 194 on inquiry card.

California Digital

Post Office Box 3097 B • Torrance, California 90503



FREE

Plastic library case supplied with all diskettes purchased from California Digital.

DISKETTES AS LOW AS $16.50

FIVE INCH SINGLE SIDED DOUBLE DENSITY	Soft Sector / Ten Sector / Sixteen	Each box	10 Boxes	100 Boxes
CAL DIGITAL	CAL-501 / CAL-510 / CAL-516	19.95	18.50	16.50
SCOTCH	MMM-744/0 / MMM-744/10 / MMM-744/16	26.50	24.50	21.75
VERBATIM	VRB-525/01 / VRB-525/10 / VRB-525/16	26.50	25.25	23.50
MEMOREX	MRX-3481 / MRX-3483 / MRX-3485	26.50	22.25	18.75
MAXELL	MXL-MD1 / MXL-MH1/10 / MXL-MH1/16	26.50	24.50	23.25
DYSAN	DYS-104/1D / DYS-107/1D / DYS-105/1D	35.00	33.00	30.50
FIVE INCH DOUBLE SIDED DOUBLE DENSITY				
CAL DIGITAL	CAL-551 / CAL-561 / N/A	24.95	22.75	20.50
SCOTCH	MMM-745/0 / MMM-745/10 / MMM-745/16	39.95	37.95	31.25
VERBATIM	VRB-550/01 / VRB-550/10 / VRB-550/16	39.95	37.95	32.75
MEMOREX	MRX-3491 / MRX-3493 / MRX-3495	35.00	31.25	26.25
MAXELL	MXL-MD2 / MXL-MD2/10 / MXL-MD2/16	39.95	37.95	34.75
MAXELL / 96	MXL-MD2/96 / N/A / N/A	45.00	43.00	41.25
DYSAN	DYS-104/2D / DYS-107/2D / DYS-105/2D	42.50	40.50	35.50
DYSAN / 96	DYS-204/2D / N/A / N/A	49.95	47.95	45.75
EIGHT INCH SINGLE SIDED SINGLE DENSITY				
SCOTCH	MMM-740/0	29.50	27.50	23.80
MEMOREX	MRX-3062	27.75	26.60	22.25
VERBATIM	VRB-34/9000	31.50	29.50	25.60
DYSAN	DYS-3740/1	35.75	32.75	29.75
EIGHT INCH SINGLE SIDED DOUBLE DENSITY				
SCOTCH	MMM-741/0	37.75	35.15	29.15
MEMOREX	MRX-3090	35.50	33.50	27.15
VERBATIM	VRB-34/8000	35.25	33.25	28.75
DYSAN	DYS-3740/1D	40.75	38.75	32.25
MAXELL	MXL-FD1	45.50	39.75	35.15
EIGHT INCH DOUBLE SIDED DOUBLE DENSITY				
SCOTCH	MMM-743/0	47.50	44.25	37.50
MEMOREX	MRX-3102	39.25	36.75	31.50
VERBATIM	VRB-34/4001	41.75	37.50	32.25
DYSAN	DYS-3740/2D	54.65	49.75	40.50
MAXELL	MXL-FD2	52.50	48.75	40.45

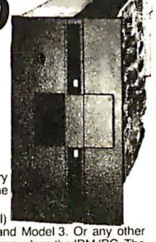
New Location



California Digital has just purchased a new distribution center six times the size of our existing facility. The new warehouse and retail store is in the city of Carson at 17700 Figueroa Street. We are located just off the San Diego Freeway near the Goodyear Blimp. Please stop by and visit our retail store when in the Los Angeles area. Store hours are 10 AM to 5 PM Monday through Saturday.

SPECIAL

Shugart 410 $129



These Shugart 410 5¼" disk drives are all factory fresh 1983 production, recently purchased from the Four Phase Division of the Motorola Corporation.

These disk drives are **single sided 80 track** (96 TPI) suitable for use with the Radio Shack Model 1 and Model 3. Or any other application that can support an 80 track second drive such as the IBM/PC. The 410 is full height and functionally the same as the Tandon TM 100-3. Complete with power connector and installation manual.

When these Shugart 410's are liquidated the price will revert to our regular price of $249. SHU-SA410

MEMORY

16K DYNAMIC	2732 EPROM
1.95	4.95
4116 150ns.	450ns.
2764 EPROM	**16K STATIC**
6.95	4.95
350ns.	6116 200ns.



4164 DYNAMIC MEMORY 150ns $5.95

DYNAMIC MEMORY

		1-31	32 +	100 +
40274K dynamic 250ns.	ICM-4027250	1.99	1.85	1.75
4116150ns. 16K	ICM-4116150	1.75	1.65	1.45
4116 200ns.16K	ICM-4116200	1.75	1.65	1.45
4164150ns.64K 128 refresh	ICM-4164150	5.95	5.85	5.55
41256 150ns.256K	ICM-41256150	Available Mar.84		
DP8409 dynamiccontroller	ICT-8409	39.00	35.00	29.00
EPROMS				
2708450ns. 1K x 8	ICE-2708	4.95	4.75	4.55
2716 450ns. 2K x 8	ICE-2716	4.50	4.25	3.97
2716TMS 450ns. Tri-voltage	ICE-2716TMS	7.95	7.65	7.25
2732450ns. 4K x 8	ICE-2732	4.50	3.75	3.55
2732 350ns. 4K x 8	ICE-2732350	8.50	8.00	7.60
2532450ns. 4K x 8	ICE-2532	10.50	9.90	9.50
2764350ns.8K x 8	ICE-2764	6.95	6.95	6.95
27128 350ns. 16K x 8	ICE-27128	18.95		
STATIC MEMORY				
21L02 200ns. 1K static	ICM-21L02200	1.49	1.29	1.15
21L02450ns. 1K static	ICM-21L02450	1.29	1.15	.99
2112 450ns.2K static	ICM-2112450	2.99	2.85	2.75
2114 300ns. 1K x 4	ICM-2114300	1.95	1.85	1.75
4044TMS 450ns. 4K x 1	ICM-4044450	3.49	3.25	2.99
5257 300ns. 4K x 1	ICM-5257300	2.50	2.25	1.99
6116 P4200ns. 2K x 8	ICM-6116200	4.85	4.65	4.50
6116P3150ns. 2K x 8	ICM-6116150	5.25	4.05	4.85
6167/2167 100ns. 16K x 1 (20pin)	ICM-6167100	9.95	9.50	

CONNECTORS



S-100 Gold



DB25P

GOLD S-100 EDGE CARD CONNECTORS	catalog	each	10-99	100+
Imsais/t .250"	CNE-IMS	2.95	2.50	2.19
Sullins Hi/Rel.	CNE-H100	4.19	3.85	3.47
S-100 Wire W.	CNE-W10	3.95	3.50	3.19
Altair .140" s/t	CNE-100A	4.95	4.50	4.19
.156" CENTER EDGE CARD CONNECTORS				
22/44 Eyelet	CNE-44E	2.50	2.15	1.95
43/72 Moto. s/t	CNE-72S	6.60	6.15	5.75
36/72 D/G s/t	CNE-72S	5.95	5.50	5.19

Otherconnectors availableuponrequest.

RIBBON CONNECTORS				
DB25P male	CND-r25P	5.65	5.25	4.15
DB25S female	CND-r25S	5.95	5.59	4.50
57-30360 male	CNC-r36P	7.95	6.75	5.90
57-30360f'male	CNC-r36S	7.95	6.75	5.90
20 pin edge	CNI-DE20	4.35	3.30	2.50
20 pin socket	CNI-DS20	2.75	1.85	1.60
26 pin edge	CNI-DE26	4.95	3.50	2.70
26 pin socket	CNI-DS26	3.50	2.40	2.15
34 pin edge	CNI-DE34	4.95	4.50	3.50
34 pin socket	CNI-DS34	4.50	3.95	3.15
50 pin edge	CNI-DE50	5.95	5.60	4.90
50 pin socket	CNI-DS50	4.95	4.60	3.80

"D" TYPE	catalog	each	10-99	100+
DE9P male	CND-9P	1.60	1.40	1.30
DE9S female	CND-9S	2.25	2.00	1.30
DE hood	CND-9H	1.50	1.35	1.20
DA15P male	CND-15P	2.35	2.10	1.90
DA15S female	CND-15S	3.25	3.10	2.90
DA15 hood	CND-15H	1.60	1.35	1.30
DB25P male	CND-25P	1.95	1.75	1.35
DB25S female	CND-25S	2.95	2.55	1.65
DB25 hood	CND25H	1.35	1.15	.77
DC37P male	CND-37P	4.20	3.95	3.65
DC37S female	CND-37S	5.95	5.75	5.50
DC37 hood	CND-37H	2.25	1.95	1.65
DD50P male	CND-50P	5.50	5.10	4.75
DD50 hood	CND-50H	2.60	2.40	2.10
Hardware 2/set	CND-2HS	.89	.69	.42
AMPHENOL / CENTRONICS TYPE				
57-30360 36/P	CNC-36P	7.95	6.35	3.97
IEEE488, C'dor	CND-24P	7.95	6.35	5.35
DISK DRIVE POWER CONNECTORS				
8" 6 pin D.C.	CNP-6DC	1.95	1.29	.89
8" 3 AC Sgl/S	CNP-3SS	1.69	1.09	.69
8" 3 AC Dbl/S	CNP-3DS	1.69	1.09	.69
5¼" 4 pin D.C.	CNP-4DC	1.79	1.19	.99
3 pin DIN recpt.	CNP-D3P	2.59	1.99	1.59

BLOWOUT SALE $169



California Digital has recently participated in the purchase of several thousand Siemens FDD 100-8 floppy disk drives. These units are electronically and physically similiar to that of the Shugart 801R. All units are new and shipped in factory sealed boxes. Manual and power connectors supplied free upon request. Your choice 115 Volt. 60 Hz. or 230 Volt. 50Hz.

NOTE! European customers, we have a large quantity of 230 volt 50 Hz. units warehoused in Frankfort Germany. Arrangements can be made to will call these drives in quantities of 50 or more in Frankfort reducing import duty and freight charges.

REMEX DOUBLE SIDED $219

California Digital has just purchased a large quantity of Remex RFD-4000 **Eight inch double sided** disk drives. Remex is the only double sided disk drive that has an double gimbal mounted head assembly that guaranties lower head tracking. This drive is mechanically solid. Remex has always been known for producing premiere products for the floppy disk market. The Remex company is a subsidiary of the Ex-cell-o Corporation, a Fortune 500 Company.

Eight Inch Single Sided Drives	One	Two	Ten
SHUGART 801R	385	375	365
SIEMENS FDD 100-8	169	169	159
TANDDN 848E-1 Half Height	369	359	349
Eight Inch Double Sided Drives			
SHUGART SA851R	495	485	475
QUME 842 "QUME TRACK 8"	459	459	449
TANDON 848E-2 Half Height	459	447	435
REMEX RFD-4000	219	219	209
MITSUBISHI M2894-63	447	439	433
MITSUBISHI M2896-63 Half Ht.	459	449	409
Five Inch Single Sided Drives			
TEAC FD-55A half height	179	169	165
SHUGART SA400L	235	229	225
SHUGART SA410 96TPI/80 Trk.	129	129	119
SHUGART SA200 ⅔ Height	159	149	139
TANDON TM100-1	189	179	175
Five Inch Double Sided Drives			
TEAC FD55B half height	219	209	199
CONTROL DATA 9409 IBM/PC	259	249	239
REMEX RFD480 IBM/PC	199	189	175
SHUGART SA450	319	309	299
SHUGART SA455 Half Height	259	249	239
SHUGART SA465 Half Ht. 96TPI	289	279	269
TANDON TM50-2 Half Height	215	209	199
TANDON TM55-4 half Ht. 96TPI	329	319	309
TANDON 100-2	279	269	259
TANDON 101-4 96TPI 80 Track	369	355	350
MITSUBISHI 4851 Half Height	259	249	245
MITSUBISHI 4853 ½ Ht. 96TPI	339	329	319
MITSUBISHI 4854 ½ Ht., 8" elec.	465	449	439
QUME 142 Half Height	239	229	219
Three Inch Disk Drives			
SHUGART SA300 with diskette	229	219	209
Five Inch Winchester Hard Disk Drives			
SHUGART 612 13 M/Bytes	895	865	825
SHUGART 706 6 M/Byte, Half Ht	795	775	755
SHUGART 712 13 M/Byte, ½ Ht.	895	865	825
TANDON 503 19 M/Byte	895	875	855

Upon request, all drives are supplied with power connectors and manual.

ENCLOSURES

California Digital manufactures an asortment of stock and custom disk drive enclosures. If the volume is justified we will custom design an enclosure for your application. The following stock disk drive enclosures are available. All include power supplies the 8" enclosures are supplied with exhaust fans.

Horizontal mount two 8" full height drives. $279.00

Vertical mount two full height 8" disk drives. $299.00

Horizontal mount one full height or two half height 8" disk drives. $239.00

Vertical mount two full height 5¼" disk drives $139.00

Telex 753607

VISA

master charge

Shipping: First five pounds $3.00, each additional pound $.50. Foreign orders: 10% shipping, excess will be refunded. California residents add 6½% sales tax. ● COD's discouraged. Open accounts extended to state supported educational institutions and companies with a strong "Dun & Bradstreet" rating. Retail location: 17700 Figueroa Street, Carson CA. 90248.

TOLL FREE ORDER LINE

(800) 421-5041

TECHNICAL & CALIFORNIA

(213) 643-9001

When this ad was prepared in early January, the telephone company was unable to assign the telephone number for our new distribution center. Please call the above number for referral.

California Digital

Post Office Box 3097 B • Torrance, California 90503

$35 WESTERN UNION EasyLink

California Digital has recently contracted with the Western Union Telegraph Company for the privledge of offering subscriptions to Western Union's new EasyLink data communications network.

Subscribers are able to transmit and receive domestic and international communications from a network of over 1.5 million Worldwide Telex subscribers. EasyLink also allows access to other Western Union services that till recently have been available only to dedicated Telex installations.

Send telegrams, Mailagrams and computer letters as easy as telephoning Western Union's toll free access line. Your personal computer and modem become your link to the World.

One time $35.00 Installation fee includes EasyLink self teaching user manual, Telex directory and your EasyLink access password.

FREE

Your Choice
Second Drive or Monitor

SANYO IBM COMPATIBLE $995



Sanyo Electronics has just released the long awaited IBM/PC look-a-like, the MBC-550. This is a complete microcomputer that includes 128K/byte of memory, a 5¼" 160K/byte disk drive upgradeable to 320K/byte drives. Also includes both color composite and RGB graphics interface, low profile keyboard, and parallel printer port. Extensive software such as Sanyo Basic, disk utilities, Wordstar word processing software, Calcstar spread sheet & Easy Writer I. MS-DOS is supplied with the Sanyo computer. Most programs written for the IBM/PC will operate on the MBC-550.

Along with all this California Digital offers "FREE" your choice of either a second disk drive, or a high resolution green or amber screen monitor. All at the super low price of only $995.

We are currently experiencing an initial shortage of this computer. Please place your orders early. The MBC-550 will be shipped on a first ordered basis.

PRINTERS



$289 Star Gemini

MATRIX PRINTERS

StarGemini-10X 120 char/sec.	STR-G10X	289.00
StarGemini-15X. 100char/sec. 15" paper.	STR-G15X	419.00
Star Gemini Delta 10. 160Char/sec	STR-D10	495.00
StarCoex 80FT friction & tractor	VST-C80FT	229.00
Toshiba P1350. 192char/sec. letterquality	TOS-1350	1495.00
Okidata 82A serial & parallel 9½" paper	OKI-82A	379.00
Okidata 92A parallel interface. 160 char/sec.	OKI-92A	479.00
Okidata 83A & parallel 15" paper	OKI-83A	619.00
Okidata 84A & parallel 15" paper	OKI-84A	1019.00
Okidata 2350 (new) 350 char/sec	OKI-2350	1995.00
Epson FX80. 10" 160 char./sec. with graphtrax	EPS-FX80	529.00
Epson MX100 with graphtrax. 15" paper	EPS-MX100	589.00
NEC8023A parallel 9½" paper. graphics	NEC-8023A	389.00
Anadex 9501A high speed with graphics	ADX-9501A	1099.00
Anadex 9620A 200 char/sec. par'l & serial.	ADX-9620A	1199.00
Quantex 7030 corespondence quality 180 char/sec.	QTX-7030	1595.00
Gorilla low cost dot matrix printer	PRO-7500	189.00
Prowriter 8510 parallel 9½" paper	PRO-8510P	359.00
Prowriter II. parallel 15" paper. graphics	PRO-2P	689.00
Dataproducts B-600-3. band printer 600 LPM.	DPS-B600	6985.00
Printronix P300 high speed printer 300 lines per minute.	PTX-P300	425000
Printronix P600 ultra high speed 600 lines per minute.	PTX-P600	5795.00
Transtar 130P par'l. IBM/PC compatible	TNS-130P	629 00

WORD PROCESSING PRINTERS

NEC7710 55 char/second. serial interface	NEC-7710	1979.00
NEC7730 55 char/sec. par'l interface.	NEC-7730	1979.00
NEC3550 popular printer designed for the IBM/PC	NEC-3550	1799.00
NEC2050 designed for IBM/PC 20 char/sec. par'l.	NEC-2050	995.00
Silver Reed EXP500. 14 char/sec. par'l interface	SRD-EXP500	459.00
Silver Reed EXP550 17 Char/sec par'l interface.	SRD-EXP550	659.00
Diablo 630 40 char/sec. serial	DBL-630	176500
Diablo 620. proportional spacing. horz.& vert. tab. 20 cps.	DBL-620	879.00
Juki 6100. 18 char./sec. graphic mode.	JUK-6100	539.00
Brother HR1A daisy wheel. parallel interface	BTH-HR1P	695.00
Brother HR1A serial interface	BTH-HR1S	779.00
Starwriter F10 serial. 40 char/sec.	PRO-F10S	1125.00
Starwriter F10 parallel. 40 char/sec.	PRO-F10P	1125.00
Comrex CR1 word processing printer. serial intr.	CRX-CR1S	729.00
Comrex CR2. 5k buffer. proportional spacing. par'l.	CRX-CR2P	495.00

MONITORS

BMC 12A green phosphor 15 MHz. composit video.	BMC-12A	79.00
BMC 12" high resolution. 20MHz.	BMC-12EN	134.00
Zenith ZVM122 Amber Phosphor 12" 40/80 column switch.	ZTH-122	119.00
Zenith ZVM123 green phosphor 12" 40/80 column switch.	ZTH-Z123	105.00
NEC JB1201 green phosphor 18 MHz. composit video.	NEC-JB1201	169.00
NEC JB1260 commercial grade composit.	NEC-JB1260	129.00
USI Amber screen 12" composit monitor.	USI-12A	169.00
Motorola 23" open frame blk/white composit video.	MOT-BW23	159.00
Motorola 12" open frame requires horz sync. and power.	MOT-BW12	69.00
Conrac 9" open frame requires horz sync. & 12v. supply.	CON-BW9	59.00
COLOR		
BMC AU9191U Color composit video with sound	BMC-9191	249.00
BMC 9191M RGB designed for use with the IBM computer.	BMC-9191M	499.00
NEC JC1203DM, RGB color monitor	NEC-1203	699.00
NEC JC1201 color composit.	NEC-JC1201	339.00
Zenith ZVM134 RGB color suitable for IBM PC	ZTH-Z134	379.00
Comrex color composit with sound	COM-6500	329.00
Amdek Color 1. composit video	AMK-100	329.00



MODEMS

DIRECT CONNECT $75

Hayes Smart Modem 1200 baud, auto answer, auto dial	HYS-212AD	499.00
Hayes 1200B for use with the IBM/PC, 1200 baud.	HYS-1200B	449.00
Hayes Smartmodem, 300 baud only, auto answer, auto dial	HYS-103AD	229.00
Hayes Micromodem II, 103 Apple direct connect	HYS-MM2	279.00
Hayes Micromodem 100, S-100 auto answer, auto dial.	HYS-100	319.00
Hayes Chronograph, time & date	HYS-CHR232	199.00
U.S. Robotics 212A 300/1200 baud, auto dial/answer.	USR-212A	439.00
U.S. Robotics Password 300/1200 baud	USR-PW212	389.00
Penril 300/1200 auto dial,autolog	PEN-12AD	695.00
Universal Data 103LP, line power, answer & originate	UDS-103LP	169.00
Universal Data 103LPJ. Auto answer	UDS-103LPJ	219.00
Universal Data 202, 1200 baud, half duplex only	UDS-202LP	219.00
Universal Data 212LP, full 1200 baud duplex, line power	UDS-212LP	359.00
Novation 'J' Cat, direct connect, auto answer	NOV-JCAT	115.00
Novation Cat. acoustic connect	NOV-CAT	159.00
Novation SmartCat 103, auto answer, auto dial	NOV-SC103	219.00
Novation SmartCat 103/212, 1200 baud auto dial	NOV-SC212	529.00
Signalman Mark 1, direct connect with terminal cable.	SGL-MK1	75.00

TERMINALS

Perkin Elmer 550S

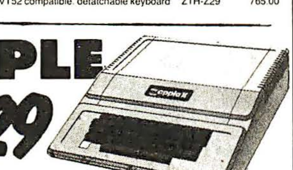


$339

California Digital has recently purchased an OEM liquidation, of new Perkin-Elmer Bantam 550S terminals. These units feature direct cursor addressing, numeric cluster, conversational or block mode transmission and RS-232 printer port. Self diagnostics and function keys make this terminal an excellent value at only $339.00. PRK-550S

Perkin-Elmer Model 550S Bantam Terminal	PRK-550S	339.00
Freedom 100. split screen, detatchable keyboard	LIB-F100	495.00
Qume 102 green phosphor terminal	QUM-102	539.00
Visual 50 Green screen	VSL-50G	650.00
Ampex Dialogue 125 green screen.	APX-D125G	675.00
Ampex Dialouge 175 amber screen, two page, func. keys	APX-D125A	719.00
Wyse 50. 14" green phosphor	WYS-50	595.00
Wyse 100. horz & vert. split screen, metal enclosure	WYS-100	795.00
Wyse 300. Eight color display, split screen.	WYS-300	1159.00
Televideo 910 Plus, block mode	TVI-910P	575.00
Televideo 925. detatchable keyboard, 22 function keys	TVI-925	759.00
Televideo 950. graphic char.,split screen, 22 func.	TVI-950	950.00
Televideo 970. 14" green screen, 132 column. European	TVI-970	1095.00
Zenith 29 terminal. VT52 compatible. detatchable keyboard	ZTH-Z29	765.00

APPLE $929



Apple II/e, 64K computer only	APL-2E	$989
Apple II/e starter kit, monitor, disk, 80 col. card.	APL-2ESK	1365
Advanced Busness Tech. 13 Key Pad	ABT-13B	109
Calif. Computer 7710A Async. Serial Interface	CCS-7710	125
Calif. Computer 7710B same but for modem	CCS-7710B	125
Calif. Computer 7114A 12K PROM module	CCS-7114	99
Calif. Computer 7720A parallel interface	CCS-7720	99
Calif. Computer 7724A Calandar/clock modual	CCS-7724	99
Calif. Computer 7729A Centronics interface	CCS-7729	99
Calif. Computer 7740A programmable timer	CCS-7740	99
California Digital 16K card for standard Apple II	CAL-A16	39
Hayes Micromodem II for Apple II	HYS-MM2	279
Kensington Micro, System saver fan	KEN-SF1	75
Microsoft Softcard with CP/M: Z-80	MSF-SFTCD	239
Mountain Computer "The Clock"	MTN-TCLK	225
Mountain Computer AD/DA 16 input, 8bit	MTN-ADDA	269
Mountain Computer ROM Plus with keybd. filter	MTN-RMF	169
Mountain Computer ROM writer/socket socket	MTN-ROMW	139
Orange Micro "GRAPPLER" parallel interface	OMS-G2	135
Sorrento Valley 8" controller double side D/D.	SVA223	395
TEAC 5¼" disk drive for Apple II	TEA-A2	269
Vista Vision 80; 80 column card for std.Apple II	VSA-VIS80	289
Vista 8" disk controller double side D/D.	VSA-A800	389

ASCII KEYBOARD $49



California Digital has purchased over 3000 of these Microswitch keyboards from the General Dynamics Corporation. 93 ASCII encoded Hall effect switches includes 8 function keys and 14 key numeric cluster make this keyboard an excellect value at only $49. MIC-93GD 5 lbs.

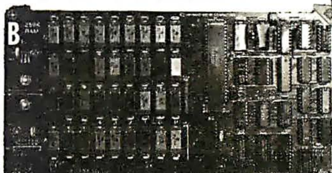
We also have available a matching General Dynamics steel trim panel. $10.

Non-encoded Hytek 58 key metal contact keyboard. HIK-58 $24.95. Matching 15 key numeric cluster $9.95. HIK-15 Both for only $29.95. HIK-5815.

Not pictured, 49 key eight bit modified Hollerith coded Microswitch Hall effect keyboard. REMOVED from punch card equipment. $14.95 DIT-KB49 ASCII encoder available.

256 KILOBYTE MEMORY BOARD

$495



- 256 kilobytes of memory using 64K dynamic RAM.
- Over one megabyte of memory using the new 256K dynamic RAM chips.
- Error detection-trap capability.
- Individual 16K block can be relocated to any boundry within a megabyte of RAM.
- 24 bit addressing and phantom mode capability.

The California Digital 256K RAM board represents an outstanding value in S-100 memory technology. Priced slighty above earlier generation 64K dynamic ram boards it gives you these additional features. 256K of memory with parity. Parity error feature can be jumpered to any of the interrupt lines, a status port, ERROR LED, or IEEE-696 *ERROR signal. 24 or 16 bit addressing with memory management.

Proper operation with front panel equipped systems, DMA disk controllers, and IEEE-696 Temporary Buss Masters assured with an on the board M1 generator for memory refresh timing. CAS and RAS timing is controlled with tapped digital delay lines for proper operation over the entire operating temperature range.

The board is very recent in design using the National Semiconductor DP-8409 RAM Controller chip. Split termination networks are used on all address lines, CAS line, and RAS lines eliminating the last traces of ringing. The board uses two separate voltage regulators. One for the DRAMs and one for the interface logic increasing the noise immunity of the ram array. Typical power dissipation is 8 watts.

Documentation includes theory of operation, configuration guide, a schematic, and application notes on the use of the memory management options. CAL-256K 2 Lbs.

S-100 BOARDS

16 BIT MICROPROCESSORS

Octagon dual CPU 8088/Z80. & controller.	OCT-88Z80	795 00
Godbout 8086/8087 microcomp. 16 bit.	GBT-8687	495.00
Godbout dual processor 8085/8088. 8/16	GBT-8588	359.00

SINGLE BOARD COMPUTERS

Insight EQ-4, 128K, 4 serial "not S-100"	INS-EQ4	595.00
Advanced Digital. Floppy & 64K	AMD-Z80	750.00
Teletek System master. 765 floppy. 64K.	TEL-SM1	895 00
Teletek FDC-1 single board. no memory	TEL-FDC1	675.00

8 BIT MICROPROCESSORS

Godbout Z80. 24 bit extended add	GBT-Z80	250.00
California Computer Z80 microprocessor	CCS-2810	275.00
Tarbell Z80 with two RS232 ports	TAR-Z80	339.00

FLOPPY DISK CONTROLLERS

Godbout Disk I, double density.	GBT-DSK1	395.00
California Computer 2422A with CPM	CCS-2422	339.00
Morrow Disk Jockey II with CPM 2.2	MDS-DJ2	350.00
Morrow Disk Jockey I with CPM, sgl. Den.	MDS-DJ1	225 00
Tarbell Electronics double density	TAR-DDC	419 00
Tarbell Electronics single density	TAR-SDC	279.00
Fulcrum DMA OmniDisk, I/O to hard disk	FCM-OD1	389.00

CPM OPERATING SYSTEM

Digital Research CP/M 3.0. 8" sgl. den.	DRC-CpM30	249.00
Godbout CPM 2 2 for Disk 1.	GBT-CpM22	159.00
Godbout CPM86 for 8088 and 8086	GBT-CpM86	26500
Tarbell Electronics CPM 2 2	TAR-CpM22	15900

HARD DISK CONTROLLERS

Octagon hard disk controller with E/C.	OCT-HD1	475.00
Godbout Disk2. 8" & 14" hard disk	GBT-DSK2	569 00
Godbout Disk3. for 5¼" Winchesters	GBT-DSK3	Nov.
Morrow Designs controller for 5¼" Win.	MDS-W506	495.00
Western Digital new WD-1001 (not S-100)	WDI-1001	49500

EPROM BOARDS

Inner Access EPROM Bd. programs 27128	IAC-P100	465.00
Digital Research PROM board. 32K	DGR-P32	119.00

STATIC MEMORY BOARDS

Godbout Ram 16. 64K 16 bit datatrans	GBT-R16	45900
Godbout Ram 17. 64K 8 bit 24 bit address	GBT-R17	35900
Godbout Ram 21 128K byte 8/16 transfer	GBT-R21	85900
Fulcrum OmniRam 8/16 transferbank	FCM-R816	395.00
California Computer 2116. 8 bit only.	CCS-2116	249.00

DYNAMIC MEMORY BOARDS

California Digital 256K expand to 1 Meg.	CAL-D256	495.00
California Comp. 2066. 64K bankselect	CCS-2066	295.00

INTERFACE BOARDS

Godbout Interfacer I. 2 serial ports	GBT-133A	239.00
Godbout Interfacer II. 1 serial 3 par'l ports	GBT-150A	269.00
Godbout Interfacer III. with 5 serial ports	GBT-135A	495.00
Godbout Interfacer III. with 8 serial ports	GBT-138A	585.00
Godbut Interfacer IV. 3 serial. 2 parallel	GBT-187A	329.00
California Computer 2710. 4 serial ports	CCS-2710	279.00
California Computer 2719. 2 serial. 2 par'l.	CCS-2719	295.00
California Computer 2720. 4 port par'l	CCS-2720	219.00
California Computer 2830. 6 port serial	CCS-2830	429.00
Morrow Designs Multiboard. 3 S/2P.	MDS-MTL1	319.00

SPECIAL FUNCTION BOARDS

Hayes S-100 Micromodem. 300 baud.	HYS-M100	325.00
QT Computer clock calendar. battery	QTC-CC100	139.00
Godbout System support board. 4K EPROM	GBT-SYS1	350.00
Godbout System support board. 9511 math	GBT-S9511	539.00
Dual Systems. 4 channel 12 bit D/A conv.	DSC-AOM12	619.00
Dual System 12 bit resolution. 32 ch A/D	DSC-AIM12	629.00
Mullins Opto-Isolator. controls 8 ch.	MUL-ICB10	179.00
Mullins extender board with logic & probe	MUL-TB4	79.00
I/O Technology wire wrap prototype	IOT-WW100	49.00
Artec Electronics wirewrap prototype	ART-WW100	25.00
Artec Electronics general purpose solder	ART-GP100	25.00

MAINFRAMES & MOTHER BOARDS

Eclipse Data. stainless. 22 slot	EDP-100	695.00
Godbout Enclosure 2. 20 slots	GBT-MF2D	675.00
California Computer 2200. 12 slot	CCS-2200	479.00
California Digital 18 slot mother board	CAL-MB18	35.00
Godbout 12 slot mother board assembled	GBT-MB12	149.00

CP/M SOFTWARE

AdaSoft CP/M	ADA-445C	395.00
D-Base II	ASH-015C	429.00
Wordstar	MPR-187C	309.00
Mailmerge	MPR-392C	169.00
Spellstar	MPR-429C	169.00
Multiplan	MSF-483C	189.00
Macro 80	MSF-187C	139.00
Supersoft	MPR-309C	149.00
MAC	DGR-401C	85.00
CP/M3.0	DGR-410C	249.00
Despool	DGR-367C	45.00
Pascal Plus	DGR-004C	429.00
CP/M86	DGR-186C	239.00
MP/M II	DGR-208C	379.00

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2102L-4	1024 x 1 (450ns) (LP)	.98
2102L-2	1024 x 1 (250ns) (LP)	1.45
2111	256 x 4 (450ns)	2.45
2112	256 x 4 (450ns)	2.95
2114	1024 x 4 (450ns)	8/7.95
2114-25	1024 x 4 (250ns)	8/8.95
2114L-4	1024 x 4 (450ns) (LP)	8/9.95
2114L-3	1024 x 4 (300ns) (LP)	8/10.95
2114L-2	1024 x 4 (200ns) (LP)	8/11.95
2147	4096 x 1 (55ns)	4.90
TMS4044-4	4096 x 1 (450ns)	3.45
TMS4044-3	4096 x 1 (300ns)	3.95
TMS4044-2	4096 x 1 (200ns)	4.45
MK4118	1024 x 8 (250ns)	9.90
TMM2016-200	2048 x 8 (200ns)	4.10
TMM2016-150	2048 x 8 (150ns)	4.90
TMM2016-100	2048 x 8 (100ns)	6.10
HM6116-4	2048 x 8 (200ns) (cmos)	4.70
HM6116-3	2048 x 8 (150ns) (cmos)	4.90
HM6116-2	2048 x 8 (120ns) (cmos)	8.90
HM6116LP-4	2048 x 8 (200ns) (cmos)(LP)	5.90
HM6116LP-3	2048 x 8 (150ns) (cmos)(LP)	6.90
HM6116LP-2	2048 x 8 (120ns) (cmos)(LP)	9.95
Z-6132	4096 x 8 (300ns) (Qstat)	33.95

LP = Low Power Qstat = Quasi-Static

DYNAMIC RAMS

TMS4027	4096 x 1 (250ns)	1.95
UP0411	4096 x 1 (300ns)	2.95
MM5280	4096 x 1 (300ns)	2.95
MK4108	8192 x 1 (200ns)	1.90
MM5298	8192 x 1 (250ns)	1.80
4116-250	16384 x 1 (250ns)	.49
4116-200	16384 x 1 (200ns)	.89
4116-150	16384 x 1 (150ns)	1.20
2118	16384 x 1 (150ns) (5v)	4.90
4164-250	65536 x 1 (250ns)	4.45
4164-200	65536 x 1 (200ns) (5v)	5.45
4164-150	65536 x 1 (150ns) (5v)	6.45

5V = Single 5 Volt Supply

EPROMS

1702	256 x 8 (1us)	4.45
2708	1024 x 8 (450ns)	2.49
2758	1024 x 8 (450ns)	2.49
2758	1024 x 8 (450ns) (5v)	5.90
2716	2048 x 8 (450ns) (5v)	2.95
2716-1	2048 x 8 (350ns) (5v)	5.90
TMS2516	2048 x 8 (450ns) (5v)	5.45
TMS2716	2048 x 8 (450ns)	7.90
TMS2532	4096 x 8 (450ns) (5v)	5.90
2732	4096 x 8 (450ns) (5v)	3.95
2732-250	4096 x 8 (250ns) (5v)	8.90
2732-200	4096 x 8 (200ns) (5V)	10.95
2764	8192 x 8 (450ns) (5v)	5.95
2764-250	8192 x 8 (250ns) (5v)	13.95
2764-200	8192 x 1 (200ns) (5v)	23.95
TMS2564	8192 x 8 (450ns) (5v)	16.95
MC68764	8192 x 8 (450ns) (5v) (24 pin)	38.95
27128	16384 x 8 Call	19.95

5v = Single 5 Volt Supply

74LS00

74LS00	.23	74LS92	.54
74LS01	.24	74LS93	.54
74LS02	.24	74LS95	.74
74LS03	.24	74LS96	.88
74LS04	.23	74LS107	.38
74LS05	.24	74LS109	.38
74LS08	.27	74LS112	.38
74LS09	.28	74LS113	.38
74LS10	.24	74LS114	.38
74LS11	.34	74LS122	.44
74LS12	.34	74LS123	.78
74LS13	.44	74LS124	2.85
74LS14	.58	74LS125	.48
74LS15	.34	74LS126	.48
74LS20	.24	74LS132	.58
74LS21	.28	74LS133	.58
74LS22	.24	74LS136	.38
74LS26	.28	74LS137	.98
74LS27	.28	74LS138	.54
74LS28	.34	74LS139	.54
74LS30	.24	74LS145	1.15
74LS32	.28	74LS147	2.45
74LS33	.54	74LS148	1.30
74LS37	.34	74LS151	.54
74LS38	.34	74LS153	.54
74LS40	.24	74LS154	1.85
74LS42	.48	74LS155	.68
74LS47	.74	74LS156	.68
74LS48	.74	74LS157	.64
74LS49	.74	74LS158	.58
74LS51	.24	74LS160	.68
74LS54	.28	74LS161	.64
74LS55	.28	74LS162	.68
74LS63	1.20	74LS163	.64
74LS73	.38	74LS164	.68
74LS74	.34	74LS165	.94
74LS75	.38	74LS166	1.90
74LS76	.38	74LS168	1.70
74LS78	.48	74LS169	1.70
74LS83	.59	74LS170	1.45
74LS85	.68	74LS173	.68
74LS86	.38	74LS174	.54
74LS90	.54	74LS175	.54
74LS91	.88	74LS181	2.10

74LS189	8.90	74LS363	1.30
74LS190	.88	74LS364	1.90
74LS191	.88	74LS365	.48
74LS192	.78	74LS366	.48
74LS193	.78	74LS367	.44
74LS194	.68	74LS368	.44
74LS195	.68	74LS373	1.35
74LS196	.78	74LS374	1.35
74LS197	.78	74LS377	1.35
74LS221	.88	74LS378	1.13
74LS240	.94	74LS379	1.30
74LS241	.98	74LS385	1.85
74LS242	.98	74LS386	.44
74LS243	.98	74LS390	1.15
74LS244	1.25	74LS393	1.15
74LS245	1.45	74LS395	1.15
74LS247	.74	74LS399	1.45
74LS248	.98	74LS424	2.90
74LS249	.98	74LS447	.36
74LS251	.58	74LS490	1.90
74LS253	.58	74LS624	3.95
74LS257	.58	74LS640	2.15
74LS258	.58	74LS645	2.15
74LS259	2.70	74LS668	1.65
74LS260	.58	74LS669	1.85
74LS266	.54	74LS670	1.45
74LS273	1.45	74LS674	9.60
74LS275	3.30	74LS682	3.15
74LS279	.48	74LS683	3.15
74LS280	1.95	74LS684	3.15
74LS283	.68	74LS685	3.15
74LS290	.88	74LS688	2.35
74LS293	.88	74LS689	3.15
74LS295	.98	74LS783	23.95
74LS298	.88	81LS95	1.45
74LS299	1.70	81LS96	1.45
74LS323	3.45	81LS97	1.45
74LS324	1.70	81LS98	1.45
74LS352	1.25	25LS2521	2.75
74LS353	1.25	25LS2569	4.20

6500

1 MHZ

6502	4.90
6504	6.90
6505	8.90
6507	9.90
6520	4.30
6522	6.90
6532	9.90
6545	21.50
6551	10.85

2 MHZ

6502A	6.90
6522A	9.90
6532A	10.95
6545A	26.95
6551A	10.95

3 MHZ

6502B	9.90

6800

68000	58.95
6800	3.90
6802	7.90
6808	12.90
6809E	18.95
6809	10.95
6810	2.90
6820	4.30
6821	3.20
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6840	11.95
6843	33.95
6844	24.95
6845	13.95
6847	10.95
6850	3.20
6852	15.70
6860	9.90
6862	10.95
6875	6.90
6880	2.20
6883	21.95
68047	23.95
68488	18.95

6800 1MHZ

68B00	9.95
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68B09E	28.95
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8237-5	20.95
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8243	10.95
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8253	6.90
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8255-5	18.95
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8257-5	8.90
8259	6.85
8259-5	7.45
8271	38.95
8272	38.95
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8279-5	9.00
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8284	14.95
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8287	6.45
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8289	48.95

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Z80-SIO/1	11.95
Z80-SIO/2	11.95
Z80-SIO/9	11.95

4.0 MHZ

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Z80A-SIO/0	12.95
Z80A-SIO/1	12.95
Z80A-SIO/2	12.95
Z80A-SIO/9	12.95

6.0 MHZ

Z80B-CPU	9.95
Z80B-CTC	12.95
Z80B-PIO	12.95
Z80B-DART	12.95

ZILOG

Z6132	33.95
Z8671	38.95

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1797	48.95
2791	53.95
2793	53.95
2795	58.95
2797	58.95
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AY5-1013	3.90
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8T26	1.54
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8T95	.88
8T96	.88
8T97	.88
8T98	.88
DM8131	2.90
DP8304	2.24
DS8835	1.94
DS8836	.98

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7805T	.74	7905T	.84
78MO5C	.34	7908T	.84
7808T	.74	7912T	.84
7812T	.74	7915T	.84
7815T	.74	7924T	.84
7824T	.74	7905K	1.44
7805K	1.34	7912K	1.44
7812K	1.34	7915K	1.44
7815K	1.34	7924K	1.44
7824K	1.34	79L05	.78
78L05	.68	79L12	.78
78L12	.68	79L15	.78
78L15	.68	LM323K	4.90
78H05K	9.90	UA78S40	1.90
78H12K	9.90		

C,T = TO-220 K = TO-3 L = TO-92

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4 POSITION	.84
5 POSITION	.89
6 POSITION	.89
7 POSITION	.94
8 POSITION	.94

IC SOCKETS

	1-99	100
8 pin ST	.12	.10
14 pin ST	.14	.11
16 pin ST	.16	.12
18 pin ST	.19	.17
20 pin ST	.28	.26
22 pin ST	.29	.26
24 pin ST	.29	.26
28 pin ST	.39	.31
40 pin ST	.48	.38
64 pin ST	4.20	call

ST = SOLDERTAIL

8 pin WW	.58	.48
14 pin WW	.68	.51
16 pin WW	.68	.57
18 pin WW	.98	.89
20 pin WW	1.04	.97
22 pin WW	1.34	1.23
24 pin WW	1.44	1.30
28 pin WW	1.64	1.44
40 pin WW	1.94	1.75

WW = WIREWRAP

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28 pin ZIF	8.90

ZIF = TEXTOOL (Zero Insertion Force)

CRYSTALS

32.768khz	1.69
1.0 mhz	3.69
1.8432	3.69
2.0	2.69
2.097152	2.69
2.4576	2.69
3.2768	2.69
3.579535	2.69
4.0	2.69
5.0	2.69
5.0688	2.69
5.185	2.69
5.7143	2.69
6.0	2.69
6.144	2.69
6.5536	2.69
8.0	2.69
10.0	2.69
10.738635	2.69
14.31818	2.69
15.0	2.69
16.0	2.69
17.430	2.69
18.0	2.69
18.432	2.69
20.0	2.69
22.1184	2.69
32.0	2.69

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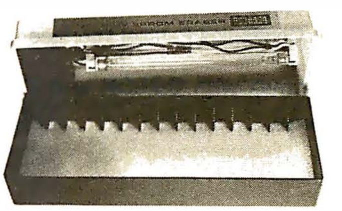
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2732	32K EPROMS	3.95
2764	64K EPROMS	5.95
27128	128K EPROMS	19.95
4164	64K DYNAMIC 250ns	4.45
4164	64K DYNAMIC 200ns	5.45
4164	64K DYNAMIC 150ns	6.45
2114	450ns	8/7.95

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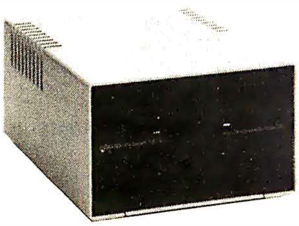
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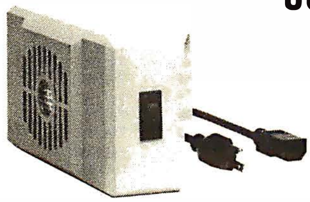
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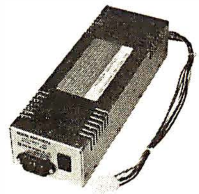
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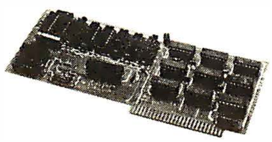
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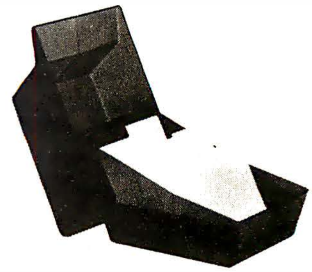
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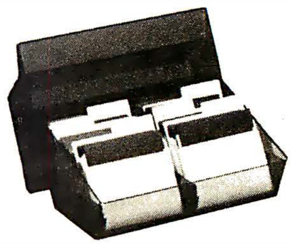
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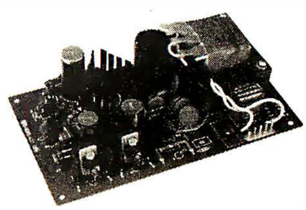
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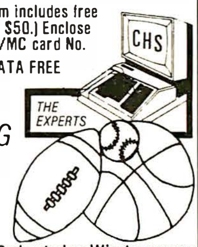
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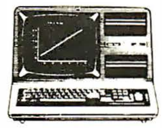
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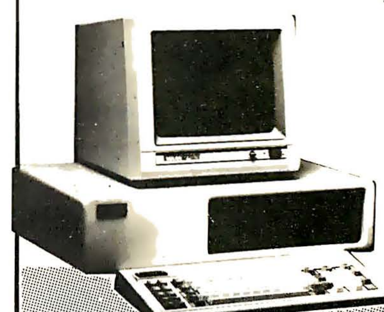
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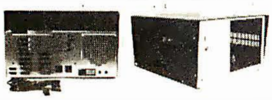
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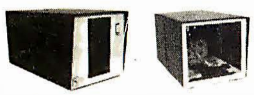


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- Power interface cable for any 8" drive

QTC-DDC88V For 2 standard size 8" drives	269.00
QTC-DDC88T For 2 thinline 8" drives	269.00
QTC-DD8'/ For 1 ea 8" drive	249.00

For 2 ea 8" standard size drives (horizontal)

- Power supply (+5V6A/-5V1A/+24V6A)
- Interface cable for any 8" drive

QTC-DDC88H	269.00

DATA CABLES

8"DSC 88-2SKT-for 2-8" drvs w/skt. conn.	20.00
5¼"DSC55-2SKT-for 1-5¼" dvs w/skt. conn.	20.00
RS232MM-5' (male to male)	19.00
IBM to PAR or COLUMBIA to PAR	32.00
Osborne to PAR	32.00
Kaypro to PAR	32.00
OKI-Data Serial	24.00

S-100 PRODUCTS

QT PRODUCTS

QT S-100 CARD CAGES

•Made of anodized steel•Card guides for ea. MB• 1-Indicates w/MB•2-Indicates w/MB +1 ea fan •3-Indicates w/MB +2 ea fans

CC4	20.00
CC4-1	60.00
CC6	22.00
CC6-1	70.00
CC6-2	90.00
CC8	31.00
CC8-1	100.00
CC8-2	120.00
CC12	41.00
CC12-1	140.00
CC12-2	160.00
CC12-3	180.00
CC18	50.00
CC18-1	200.00
CC18-2	220.00
CC18-3	240.00
CC22	75.00

QT S-100 MOTHERBOARDS

•Silence Plus•Built in Termination•IEE696•Terminal strip for easy power connection

4 Slot Motherboards	
QTC-MB4BB	15.00
QTC-MB4A	40.00
6 Slot Motherboards	
QTC-MB6BB	20.00
QTC-MB6A	48.00
8 Slot Motherboards	
QTC-MB8BB	25.00
QTC-MB8A	69.00
12 Slot Motherboards	
QTC-MB12BB	30.00
QTC-MB12A	99.00
18 Slot Motherboards	
QTC-MB18BB	45.00
QTC-MB18A	150.00
22 Slot Motherboards	
QTC-MB22BB	60.00
QTC-MB22A	185.00

QT/COMPUTIME BOARD SET

PN-2048 Best Bare Board Set Available

QTC-SBC 2/4 CPU (SBC 880)
QTC-EXP + III 256K (CT256) Memory bd./ Expandable to 1 MG
QTC-FDC 5/8 Floppy disk controller

Bare Board Set	165.00

1) Includes manuals & assembly instructions
2) Parts available 3) Monitor & B10S available

QT COMPUTIME CLOCK/CALENDAR

S-100•Time in hrs, min, sec.•AM/PM or Military Format•Date in Mo., Day, Yr., Day of Week & Leap Year recognition•4 hard interrupts (1024 Hz, 1 Hz 1 min, 1 hr)•On board battery (will last 14 mos. w/no power on)

QTC-CCS-BB (S-100)	45.00
QTC-CCS-A (A+T) for S-100	100.00

CPU BOARDS/MEMORY BOARDS/I/O

QTC-SBC 2/4 BB (SBC880)	50.00
QTC-SBC 2/4 AA + T (SBC880)	265.00
DYNAMIC (64K/256K or 1 MEG)	
QTC-EXP + III Bare Bd. (CT256)	75.00
QTC-EXP + III 64K A + T (CT256)	375.00
QTC-I/O + BB 2 SER 2 PAR A + T	75.00
QTC-I/O + A + T	300.00
QTC-ADA ADA Converter A + T	575.00
QTC-Dual GPIB-488 IEEE 488 Interface Bd.	795.00

COMPUPRO PROD.

CompuPro®

SYSTEMS

System 816A	4,395.00
System 816A with RAM 21	4,569.00
System 816A - H40	7,169.00
System 816B	5,595.00
System 816B - H40	8,349.00
System 816C	7,150.00
System 816C - H40	9,999.00
System 816D	11,099.00
System 816D - H40	13,995.00
System 816E (68K)	7,150.00
System 816E - H40	9,999.00
System 816Z	3,999.00
System 816Z - H40	6,725.00

CPU BOARDS

CPU Z 6 MHz	245.00
CPU 8085/88 - 6/8 MHz	369.00
CPU 8086 - 8 MHz	650.00
CPU 8086 - 10 MHz	750.00
CPU 68K - 8 MHz	575.00
SPUZ (March '84)	575.00

MEMORY BOARDS

RAM 16	475.00
RAM 17-64	369.00
RAM 21	839.00
RAM 22	1,475.00
M-DRIVE H	1,199.00

INTERFACE BOARDS

Interfacer 1	220.00
Interfacer 2	245.00
Interfacer 3	575.00
Interfacer 4	349.00

DISK CONTROLLERS

Disk 1	399.00
Disk 1A	575.00
Disk 2 (In 1. CP/M 80)	750.00
Disk 3	750.00

DISK DRIVE SUBSYSTEMS

8" Floppy/H-40	4,595.00
8" Dual H-40 w/encl.	6,000.00
Dual Floppy Subsystem	2,695.00

MOTHERBOARDS AND COMPUTER ENCLOSURES

6 Slot Motherboard	129.00
12 Slot Motherboard	149.00
20 Slot Motherboard	220.00
Enclosure 2-D	739.00
Enclosure 2-R	795.00

MISCELLANEOUS BOARDS/CONTROLLERS

Memory Manager	75.00
System Support 1	349.00
MPX 1	495.00
Active Terminator	60.00
8087 Support Board for 8085/88	379.00

WARRANTY: 1 year from date of purchase by end user

OPERATING SYSTEMS

CP/M 80 2.2 (Disk 1)	150.00
CP/M 86 (Disk 1 8085/88)	199.00
MP/M 8-16 (For 8085/88)	495.00
MAP FORTH OS	169.00
CP/M 68K	269.00

SIERRA DATA S-100 BOARDS

SDS-SBC-100-Z80 (4mhz) master 2 serial 2 par/ floppy controller/64k ram	655.00
SDS-SBC-100S4mhs slave/2 serial 2 par/ 64k ram	565.00
SDS-ZSIO/4-4 serial port I/O bd	250.00
SDS-MUX-RS232 multiplexer bd	235.00
SDS-HDI-M-Hard disk bd for micropolis	129.00
SDS-CPM/B105-cp/m for SBC 100 w/BIOS	150.00
SDS-Turbodos-Multi-user for master & slaves	645.00

1-801-972-2717

1780 West 2300 South **The Great Salt Lake Computer Co.** Salt Lake City, Utah 84119

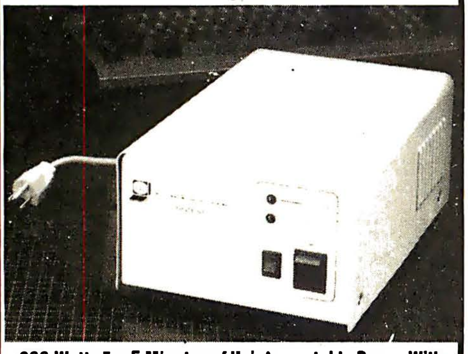
Circle 169 on inquiry card.

PRIORITY ONE ELECTRONICS

SANYO CP/M® COMPUTER + PRINTER = $1795

NOW! The Affordable UPS For Your Personal Computer!

PTI INDUSTRIES Production Technology International **$359.00**

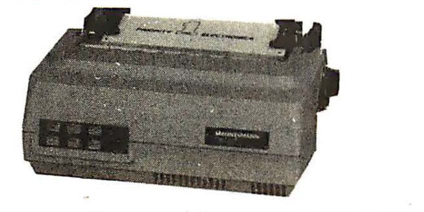


200 Watts For 5 Minutes of Uninterruptable Power With AC Surge and EMI/RFI Filtering Built In!

Perfect for Morrow Micro Decision, IBM PC™, Apple IIe, and many, many more!

BCPTIPC200 (Sh. Wt. 21 lbs.) **$359.00**

MANNESMANN TALLY



Letter Quality Dot Matrix Printer

For Complete Specifications, see page 41 of our new '83/'84 Engineering Selection Guide

BCTALMT160L	80 column/160 cps (21 lbs.)	$589
BCTALMT180L	132 column/160 cps (28 lbs)	$829
BCTALMTRIB160	Replacement Ribbon for MT160L	$15.75
BCTALMTRIB180	Replacement Ribbon for MT180L	$17.80

Order Interface Cables at Left

PIXY 3 PLOTTER

High Quality, economical 3 color plotter. See page 37 of our '83/'84 Engineering Selection for details.

BCTALPIX3P	w/parallel interface (sh. wt. 16 lbs.)	$699
BCTALPIX3S	w/serial interface (sh. wt. 16 lbs.)	$769

TAXAN



18MHz 800 Line Resolution Yields An Incredibly Sharp 80 x 24 Display!

AMBER	GREEN
BCTAXKG12NUY List: $189.00	BCTAXG12NUY List: $179.00
$129.00	$119.00
(Shipping Weight 18 lbs.)	(Shipping Weight 18 lbs.)

Buy From The World's Largest Supplier of S-100 Boards

CompuPro

CPU BOARDS

		List Price	Sale Price
BCGBT51068	CPU 68K A&T 8MHz	$ 695.00	$ 595.00
BCGBT51588	CPU 68K CSC 10MHz	$ 850.00	$ 765.00
BCGBT51086	Co-Processor w/8086 only A&T	$ 750.00	$ 675.00
BCGBT51566	Co-Processor w/8086 only CSC	$ 850.00	$ 765.00
BCGBT51067	CPU 8086/8087 A&T	$1050.00	$ 939.00
BCGBT51567	CPU 8086/8087 CSC	$1150.00	$1065.00
BCGBT51080	CPU 8085/88 A&T	$ 495.00	$ 389.00
BCGBT51580	CPU 8085/88 CSC	$ 595.00	$ 497.87
BCGBT51060	3/6MHz CPU-Z A&T	$ 325.00	$ 279.00
BCGBT51560	3/6MHz CPU-Z CSC	$ 425.00	$ 347.87

DISK CONTROLLER BOARDS

		List Price	Sale Price
BAPDB171ACPM	DISK 1 (A&T) w/CP/M® 2.2	$670.00	$489.00
	When purchased with two 8" disk drives:		$450.00
BCGBT54016	DISK 1 Floppy controller (A&T)	$495.00	$425.00
BCGBT41000	CP/M® 2.2 for Z80/8085 w/manuals & BIOS. 8" S/D Disk		$148.95
BCGBT41050	CP/M-86® for CPU 8085/88 & CPU 8086/87 CPUs w/manuals. BIOS 8" S/D Disk		$249.00
BCGBT54025	DISK 2 8" hard disk controller w/CP/M® 2.2 (A&T)	$795.00	$725.00
BCGBT54030	DISK 3 ST-506 type 5¼" hard disk controller w/CP/M-80® & CP/M-86® (A&T)	$795.00	$725.00

I/O BOARDS

		List Price	Sale Price
BCGBT56010	System Support 1 Multifunction I/O (A&T)	$450.00	$375.00
BCGBT56010/56531	SS1 w/8231 Math Chip A&T	$645.00	$570.00
BCGBT56010/56320	SS1 w/8232 Math Chip A&T	$645.00	$570.00
BCGBT53030	Interfacer 3 - 8 port serial (A&T)	$699.00	$599.00
BCGBT53040	Interfacer 4 - 3 Serial, 1 Centronics Parallel, 1 Parallel (A&T)	$450.00	$389.00

8/16 BIT MEMORY BOARDS

		List Price	Sale Price
BCGBT52016	RAM 16 12MHz 32K Static A&T	$ 550.00	$ 495.00
BCGBT52021	RAM 21 12 MHz 128K Static A&T	$ 995.00	$ 895.00
BCGBT52022	RAM 22 12MHz 256K Static A&T	$1750.00	$1549.00
BCGBT52012	M-Drive/H 512K RAM Disk A&T	$1475.00	$1195.00

MAINFRAMES

		List Price	Sale Price
BCGBT51200	20 Slot Desk Top (A&T)	$925.00	$795.00
BCGBT51250	20 Slot Rack Mount (A&T)	$975.00	$850.00

For more CompuPro Specifications see pages 2 - 33 of our New Catalog

Vector

Manufactured by Vector Electronic Co. under license from CompuPro

		List Price	Sale Price
BCVCT8800GFB	Interfacer 1, 2-Serial (A&T)	$295.00	$219.00
BCVCT8800GF2B	Interfacer 2, 3-Par., 1-Ser. (A&T)	$325.00	$239.00
BCVCT8800GR17B	RAM 17 64K 10MHz Static RAM (A&T)	$450.00	$389.00

SDSYSTEMS

A SYNTECH COMPANY

		List Price	SALE Price
BCSDS38095	SBC-300 4MHz Z80A CPU A&T	$ 741.00	$ 619.00
BCSDS38092	SBC-300 6MHz Z80B CPU A&T	$ 825.00	$ 689.00
BCSDS38007	Z80 Starter System A&T	$ 450.00	$ 399.00
BCSDS38088	ExpandoRAM IV 256K A&T	$1145.00	$ 975.00
BCSDS38089	ExpandoRAM IV 256K w/EDC A&T	$1990.00	$1675.00
BCSDS38097	ExpandoRAM III/696 256K	$ 825.00	$ 749.00
BCSDS38076	PROM-100 w/software A&T	$ 285.00	$ 219.00
BCSDS38082	RAM Disk 256K A&T	$ 875.00	$ 775.00
BCSDS38081	ROM Disc 128K A&T	$ 350.00	$ 319.00
BCSDS38096	I/O-8 4-Port Async Ser. A&T	$ 600.00	$ 549.00
BCSDS38093	I/O-8 8-Port Async Ser A&T	$ 695.00	$ 589.00
BCSDS38094	I/O-8 4 Sync, 4 Async, 8-Port Serial I/O A&T	$ 795.00	$ 699.00
BCSDS38099	Versafloppy III Floppy & ST-506 Hard Disk Controller	$ 895.00	$ 759.00
BCPDBVF339145*	w/5¼" unbanked CP/M® 3.0	$1083.00	$ 888.00
BCPDBVF339146*	w/8" unbanked CP/M® 3.0	$1083.00	$ 888.00
BCPDBVF339147*	w/5¼" banked CP/M® 3.0	$1083.00	$ 888.00
BCPDBVF339148*	w/8" banked CP/M® 3.0	$1083.00	$ 888.00
BCSDS38098	Versafloppy II/696 (A&T)	$ 400.00	$ 344.00
BCPDBVF239141*	w/5¼" unbanked CP/M® 3.0	$ 588.00	$ 424.00
BCPDBVF239142*	w/8" unbanked CP/M® 3.0	$ 588.00	$ 424.00
BCPDBVF239143*	w/5¼" banked CP/M® 3.0	$ 588.00	$ 424.00
BCPDBVF239144*	w/8" banked CP/M® 3.0	$ 588.00	$ 424.00

*CP/M-Plus™ (3.0) configured for the SBC-300

See Complete Specifications on Pages 12-25 Of Our '83/'84 Engineering Selection Guide

NEW! Octagon

BOARD LEVEL PRODUCT

		List Price	SALE Price
BCOCTCPU816	8/16 Bit SBC (A&T)	$ 895.00	$ 795.00
BCOCT8087NDP	8087 for CPU 8/16		$ 300.00
BCOCTCPM86	CP/M-86®		$ 150.00
BCOCTCONCPM86	Concurrent CP/M-86®		$ 195.00
BCOCTMPM86	MP/M-86®		$ 495.00
BCOCTHDC	ST-506 Hard Disc Controller	$ 595.00	$ 525.00
BCOCTHDSUB19	19.2Mb Hard Disc Subsystem	$2295.00	$1995.00
BCOCTS256TDD	256K Static RAM (A&T)	$1850.00	$1719.00
BCOCTC512K	512K Dynamic RAM (A&T)	$1450.00	$1345.00

See Specifications on Pages 12-27 Of Our '83/'84 Engineering Selection Guide

COMPLETE OCTAGON 8/16™ SYSTEMS

BCOCT816SMPM	w/256K Static RAM & MP/M-86™	$7350.00
BCOCT816SCCPM	w/256K Static RAM & Concurrent CP/M-86	$7350.00
BCOCT8160MPM	w/512K Dynamic RAM & MP/M-86	$7350.00
BCOCT8160CCPM	w/512K Dynamic RAM & Concurrent CP/M-86	$7350.00

See Complete Specifications on Page 5 Of Our New '83/'84 Engineering Selection Guide

Circle 292 on inquiry card.

Z80 SINGLE BOARD COMPUTERS

ADVANCED DIGITAL CORPORATION

Part Number	Description	List Price	SALE Price
BCADCSUP6128	Super Six 6MHz 128K Master w/1 ADC PS1 RS232 Serial Adapter	$995.00	$849.00
BCADCSPRSLV6128	Super Slave 6MHz 128K	$695.00	$595.00
BCADCSBC15	Super Quad for 5¼" drives	$750.00	$695.00
BCADCSBC18	Super Quad for 8" drives	$750.00	$695.00

SOFTWARE & I/O PORT ADAPTERS

BCADCPS1	PS/Net1 RS232 Serial Adapter	$ 35.00
BCADCCPSP	Centronics Parallel Port Adapter	$ 35.00
BCADCCPM22*†	Advanced Digital CP/M® 2.2	$150.00
BCADCCPM30*†	Advanced Digital CP/M Plus™ (3.0)	$350.00
BCADCTDOS4U*†	TurboDos® 1, 2, or 4 Multi-user	$550.00

*Replace * with Q to specify Super Quad; S for Super Six

† Replace † with 8 for 8" IBM® 3740 format, 48 for 5¼" 48 TPI format or 96 for 5¼" 96 TPI format.

ST506/SA1000 HARD DISK CONTROLLER

		List Price	SALE Price
BCADCHDC10015	ST506 5¼" Winchester Cont.	$500.00	$450.00
BCADCHDC10018	8" Winchester Cont.	$500.00	$450.00
BCADCHDCINSTL	Install program for use with non-ADC CPU board (Supplied on 8" CP/M® compatible disk)		$ 10.00

See Complete Specifications on Pages 14 - 27 of our '83/'84 Engineering Selection Guide

MACROTECH International Corp.

MAX: 1 S-100 SLOT 1 MEGABYTE

The MACROTECH MAX is a 256K to 1 Megabyte S-100 IEEE/696 dynamic memory board. That's right, up to 1 Megabyte on a single standard size S-100 board. The first 384K is on the Host card that plugs into your motherboard. The remaining 640K is located on a unique "piggy-back" card that attaches to the host. The MAX family is ideally suited to applications where density, speed, and software flexibility are essential.

See Page 16 Of Our New '83/'84 Engineering Selection Guide for Complete Specifications

Ordering Information: The 256K and 384K versions include the fully socketed Host card. The 512K and larger versions also include the fully socketed "piggy-back" card.

		List Price	SALE Price
BCMACMAX256	256K Dynamic RAM (A&T)	$1125.00	$1165.00
BCMACMAX384	384 Dynamic RAM (A&T)	$1467.00	$1395.00
BCMACMAX512	512K Dynamic RAM (A&T)	$1880.00	$1795.00
BCMACMAXM	1 MEG Dynamic RAM (A&T)	$2449.00	$2325.00
BCMACMAXTM	MAX Technical Manual		$ 15.00
BCMACMAXVDSK	MAX Virtual Disk Software supplies on 8" S/D Disk		$ 25.00
BCMACM3	Memory Mapping Option		$ 91.00

Attention CompuPro CPU 8085/88 Users: You must order the CPU modification hardware to insure complete compatibility.

BCMACGBTMOD	Hardware modification for CompuPro CPU 8085/88	$ 10.00

ORDER TOLL FREE (800) 423-5922 - CA, AK, HI CALL (818) 709-5111

PRIORITY ONE ELECTRONICS

SEE PAGE 392 IN FEBRUARY BYTE

DRIVES & ENCLOSURES

5¼" FLOPPY DISK DRIVES

BCMPI51*	MPI Full Height SS 48TPI (5 lbs.)	$200.00
BCMPI52*	MPI Full Height DS 48TPI (5 lbs.)	$270.00
BCMPI91*	MPI Full Height SS 96TPI (5 lbs.)	$275.00
BCMPI92*	MPI Full Height DS 96TPI (5 lbs.)	$400.00
BCMPI501	MPI ½-Height SS 48TPI (4 lbs.)	$260.00
BCMPI502	MPI ½-Height DS 48TPI (4 lbs.)	$300.00
BCTNDTM1001	Tandon Full Height SS 48TPI	$199.00
BCTNDTM1002	Tandon Full Height DS 48TPI	$249.00
BCTNDTM1014	Tandon Full Height DS 96TPI	$339.00

*Replace with M for MPI Door, or S for Shugart SA400 Type Door

5¼" Disk Drive Cabinets

BCJMR1C5	Single Drive Cabinet (5 lbs.)	$ 79.00
BCJMR2C5	Dual Drive Cabinet (9 lbs.)	$ 99.00
BCJMR2C5C	Dual w/Internal Data Cable (9 lbs.)	$115.00

8" Floppy Disk Drives

BCSHU801R	Shugart Full Height SS (18 lbs.)	$349.00
BCSHU851R	Shugart Full Height DS (18 lbs.)	$479.00
BCSIEFDD100B	Siemens Full Height SS (18 lbs.)	$169.00
BCQMETRAK842	Oume Full Height DS (18 lbs.)	$459.00
BCMITM289483B	Mitsubishi Full Height DS (18 lbs.)	$375.00
BCMPI41S	MPI Full Height SS (11 lbs.)	$380.00
BCMPI42S	MPI Full Height DS (11 lbs.)	$460.00
BCMPI410	MPI Dual ½-Height SS (22 lbs.)	$760.00
BCMPI42D	MPI Dual ½-Height DS (22 lbs.)	$830.00
BCMPI41M	MPI ½-Height SS (9 lbs.)	$380.00
BCMPI42M	MPI ½-Height DS (9 lbs.)	$460.00
BCTNDTM8481	Tandon ½-Height SS (9 lbs)	$359.00
8CTNDTM8462	Tandon ½-Height DS (9 lbs.)	$435.00

Dual 8" Disk Enclosures

All of these rugged enclosures feature forced, filtered air cooling, hefty power supply, with the heat producing elements mounted to outside for cool, reliable operation. The rear panels are punched for the appropriate data cables.

FDE002. Economical design for two standard size 8" floppies. Hinged lid for easy drive access. Power supply: 5V@4A, -5V@.8A, +24@3A.

DTL002. Cabinet for two ½-height 8" drives or 1 full height 8" floppy or Winchester. Includes Shugart type AC power cable.

Part Number	Description	List Price	SALE Price
BCIIIFDE002	FDE002 Dual Enc. (35 lbs.)	$359.95	$325.00
BCIIIDTL002SHU	DTL002 Dual Thin Line (12 lbs)	$225.00	$175.00
BCIIIDTLMPIKIT	MPI ½-Height DTL adapter kit		$ 24.95
BCIIICBLSQN304FM	Shugart to Qume AC Cable		$ 4.95

BUY CABINETS WITH DRIVES AND $AVE!

WOW!!
2 SIEMENS FDD1008s !!
8" SINGLE SIDED DOUBLE DENSITY
&
IIIFDE002 Cabinet
$499.00
BCPDBIIISIE

Combinations with FDE002

BCPDBIIIFDE2S2	w/2 SHU801R Drives	$ 969.00
BCPDBIIIFDE2M2	w/2 MFM289463BS Drives	$1049.00
BCPDBIIIFDE2Q2	w/2 QMETRAK842 Drives	$1199.00
BCPDBIIIFDE2851	w/2 SHU851R Drives	$1239.00

Combinations with DTL002

BCPDBIIITND1	w/2 TNDTM8481 Drives	$ 879.00
BCPDBIIITN02	w/2 TNDTM8482 Drives	$1039.00
BCPDBIIIMPI1	w/2 MPI41M Drives	$ 879.00
BCPDBIIIMPI2	w/2 MPI42M Drives	$1039.00

Due to UPS Regulations, drives and cabinets will be shipped separately. Please include shipping for each disk drive and cabinet.

5¼" Hard Disk

BCMCP1302	Micropolis 20.4/25.9 Mb (12 lbs.)	$1465.00
BCMCP1303	Micropolis 33.9/43.2 Mb (12 lbs)	$1875.00
BCMCP1304	Micropolis 40.8/51.9 Mb (12 lbs)	$2195.00
BCTNDTM501	Tandon 6 Mb (9 lbs)	$ 699.00
BCTNDTM502	Tandon 12 Mb (9 lbs.)	$ 649.00
BCTNDTM503	Tandon 19 Mb (9 lbs)	$ 995.00

DUAL 5¼" HARD DISK DRIVE CABINET

All of the necessary power for two TANDON TM500 series or equivalent harrl disk drives. Just imagine, you can have 100Mbytes of storage using two of the Micropolis 5¼" Winchester disk drives and this cabinet! Power supply: +5V@6A and +12V@6A. The rear panel is punched for two 20, two 34, and one 50 pin header connector. Fan cooled.

BCIIIH05D02 Dual Hard Disk Enclosure (Sh. Wt. 20 lbs) $369.00

BUY CABINET WITH DRIVES AND $AVE!

	w/2 TM501 Drives	$1599.00
BCPDB502HD5	w/2 TM502 Drives	$1899.00
BCPDB503HD5	w/2 TM503 Drives	$2149.00
BCPDB1302HD5	w/2 MCP1302 Drives	$2999.00
BCPDB1303HD5	w/2 MCP1303 Drives	$3799.00
BCPDB1304HD5	w/2 MCP1304 Drives	$4399.00

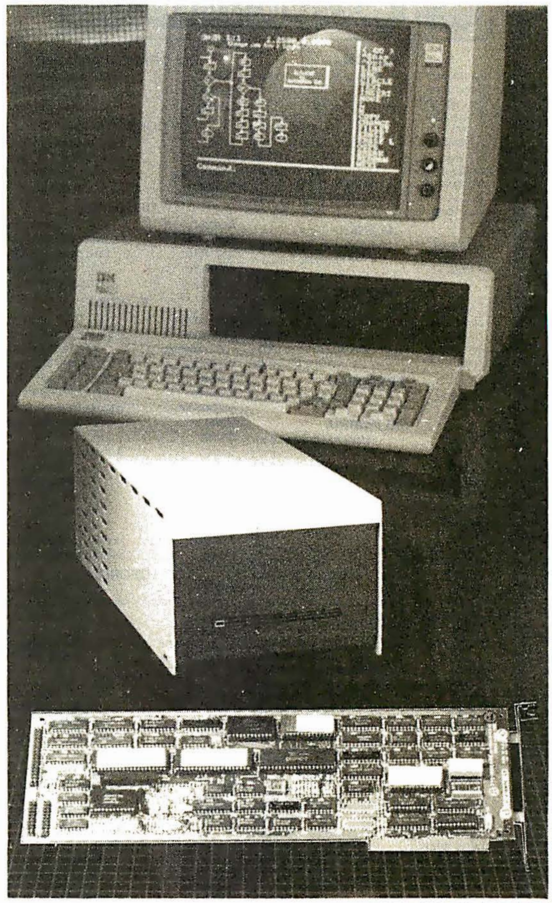
Due to UPS Regulations, disk drives will be shipped separately from cabinets. Don't forget to include shipping for each disk drive cabinet.

15M Byte Hard Disk For IBM PC™

International Instrumentation Incorporated

50% More Capacity Than The XT!™

- Plug and Run — ready to go right out of the box!
- Complete with controller card, data cable, & internal mounting hardware
- Total PC/XT Compatible — will boot directly from the hard disk under DOS 2.0
- No special software needed
- 8K BIOS emulates XT command set
- Controller will support any 2 hard drives
- Hard disk can be partitioned into 4 operating systems
- 2:1 interleaving (data transfer rate 3 times faster than XT™)



INTERNAL 15M Byte Hard Disk With Controller

$1495
BCIIIHDPCI15 (Sh. Wt. 11 lbs.)

EXTERNAL 15M Byte Hard Disk With Controller

The 15Mbyte drive is mounted in a IIIHD5001 cabinet with power supply. All hardware specifications are the same.

$1695
BCPDBIIIHDPCX15 (Sh. Wt. 16 lbs.)
External 15Mbyte Hard Disk w/Controller & Data Cable

Backed By a 6-Month Warranty!

maxell®
IT'S WORTH IT!



Go on The Gold Standard!

5¼" DOUBLE DENSITY DISKETTES

Part Number	Sectors	Tracks	Sides/ Heads	Price Per Box of 10: 1	2 or more
BCMXLMD1M	Soft	40	1	$28.00	$25.00
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- Eureka...Redwood Electronics
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- Fresno...Whitcomm Electronics
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- Glendale...Eagle Electronics
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- Tustin...A.B.C. Electronic Supply
- Vallejo...Zackit
- Van Nuys...Thrifty Electronics
- Westminster...JK Electronics
- Whittier...Whittier Electronics
- Woodland Hills...Heathkit Electronic Center
- Yuba City...Electronic World

COLORADO
- Boulder...Hapco
- Colorado Springs...Calco Digital Equip.
- Colorado Springs...Centennial Electronics
- Denver...Fistell's Electronics

COLORADO (Continued)
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- Denver...Mountain Coin Machine
- Lakewood...D.H. Crump Co.

CONNECTICUT
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- Wallingford...Tron Town USA
- Westport...Computer Works

DELAWARE
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- New Castle...Delaware Amateur Supply
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- Wilmington...Micro Products
- Wilmington...Wholesale Electronics

FLORIDA
- Coral Gables...Olson Electronics
- Clearwater...Amateur Electronic Supply
- Fort Lauderdale...Tecktron Enterprises
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- Pensacola...Pensacola Electronics
- Pensacola...Quad Electronics
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- Tampa...Heathkit Electronic Center

GEORGIA
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- Dalton...A.C.M. Computer Mart
- La Grange...Electronic Supply
- Stone Mountain...Coleman's Electronics
- Warner Robbins...C&L Electronics

HAWAII
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- Honolulu...Industrial Electronics
- Honolulu...Integrated Circuit Supply
- Pearl City...Heathkit Electronic Center

IDAHO
- Boise...Kimball Electronics
- Boise...R.J.M. Electronics
- Caldwell...A-Gem Supply
- Pocatello...Kimball Electronics
- Twin Falls...Central Electronics

ILLINOIS
- Addison...Digital World, Inc.
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- Niles...Joseph Electronic
- Peoria...Computerland
- Peoria...Warren Radio Co.
- Rockford...Computer Store of Rockford
- Rock Island...Team Electronics
- Skokie...Lilliput Computer
- South Holland...Union Electronic Dist.

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- Angola...Lakeland Electronics
- Bedford...Elex Mart
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- Chesterton...Chesterton Electronics
- Evansville...Hutch & Son
- Gary...Calumet Electronics
- Indianapolis...Heathkit Electronic Center
- Indianapolis...Warren Radio Co.
- Lafayette...Von's Electronics
- Muncie...Pierce Electronics
- South Bend...Genesis Electronics
- South Bend...TV Supply Co.
- Terre Haute...Industrial Electronics

IOWA
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- Burlington...Union Supply Co.
- Clinton...R.J.S. Electronics
- Davenport...Warren Radio Co.
- Des Moines...Gifford Brown Inc.
- Des Moines...Radio Trade Supply

KANSAS
- Hutchinson...Hutchinson Electronics
- Kansas City...Electronic Surplus Sales
- Mission...Heathkit Electronic Center
- Salina...Electronics Inc.
- Shawnee Mission...Burstein & Assoc.
- Topeka...Carroll Radio & TV Supply
- Wichita...Amateur Radio Equipment
- Wichita...Lloyd's Radio & Elex
- Wichita...R.S.C. Supply

KENTUCKY
- Lexington...Radio Electronic Equip. Co.
- Louisville...Heathkit Electronic Center
- Louisville...Peerless Electronic Equip. Co.
- Paducah...Warren Radio Co.

LOUISIANA
- Baton Rouge...Davis Electronic Supply
- Baton Rouge...Industrial Elect. Supply
- Baton Rouge...Menard Electronics
- Covington...Electronic Mart
- Gretna...Pelican Electronics
- Houma...Pelican Electronics
- Kenner...Heathkit Electronic Center
- Lake Charles...W.R.E. Inc.
- Metairie...Pelican Electronic Supply
- Meridian...Hooper Electronic Supply
- New Orleans...Wm. B. Allen Supply Co.
- Shreveport...Electronic Supply of Shreveport
- Shreveport...Industrial Electronic Supply
- Shreveport...Southern Electronics
- Slidell...Electronic Mart

MARYLAND
- Aberdeen...Harco Electronics
- Annapolis...Computers, Etc.
- Baltimore...Heathkit Electronic Center
- Beltsville...Mark Electronics
- College Park...Electronics Plus
- Damascus...Damascus C.B.
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- Rockville...Revacto Electronics
- Severna Park...Futronics Inc.
- Suitland...Suburban Wholesalers
- Towson...Baynesville Electronics
- Towson...Computers Unlimited

MASSACHUSETTS
- Danvers...Computer Electronic Consultants
- Littleton...Tel-Com Inc.
- Peabody...Heathkit Electronic Center
- Pittsfield...Pittsfield Radio Equipment
- Waltham...Computer Mart Inc.
- Wellesley...Heathkit Electronic Center

MICHIGAN
- Adrian...E&B Electronics
- Allen Park...Olson Electronics
- Ann Arbor...Wedemeyer Elect. Supply
- Battle Creek...Warren Radio
- Bay City...Kinde Distributing
- Canton...The Electronic Connection
- Dearborn...Westside Radio
- Detroit...A.F. Electronic Parts
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- Detroit...S&S Electronics
- East Detroit...Heathkit Electronic Center
- Fenton...Tri-County Electronics
- Flint...Shand Electronics
- Grand Haven...K.S. Electronics
- Grand Rapids...Micro World Inc.
- Grand Rapids...Radio Parts Inc.
- Grand Rapids...T&W Electronics
- Grand Rapids...Warren Radio
- Holland...Bits & Bytes
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- Jackson...Fulton Radio Supply
- Kalamazoo...Warren Radio
- Lansing...Fulton Radio Supply
- Lansing...Wedemeyer Elect. Supply
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- Madison Heights...Warren Radio
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- Mount Clemens...Olson Electronics
- Muskegon...H&R Electronics
- Niles...Niles Radio Supply
- Owosso...Warren Radio
- Port Huron...Main TV Radio Electric
- Saginaw...Electronic Mart
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- Sterling Heights...Electronic Supermarket
- Taylor...Electronic World
- Taylor...Tel Van Electronic Supply
- Traverse City...Traverse City Elect. Supply
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MINNESOTA
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- Winona...Hiawatha Electronics

MISSISSIPPI
- Biloxi...Hooper Electronic Supply
- Jackson...Ellington Electronic Supply
- Oxford...Oxford Software
- Pascagoula...Hooper Electronic Supply

MISSOURI
- Bridgeton...Heathkit Electronic Center
- Columbia...Show Me Electronics
- Kansas City...Burstein & Associates
- Kansas City...Electronic Supply Co. Inc.

MISSOURI (Continued)
- Kansas City...Walters Radio
- Rolla...Show Me Electronics
- Sedalia...Show Me Electronics
- Springfield...Show Me Electronics

MONTANA
- Billings...Conley Radio Supply
- Bozeman...Electronic Service & Dist.
- Great Falls...Art's Electronics
- Great Falls...Electric City Radio

NEBRASKA
- Grand Island...G.I. Electronics
- Lincoln...Computer Systems Inc.
- Lincoln...Scott Electronic Supply
- Norfolk...Caauwes Gun & Hobby Shop
- Omaha...Heathkit Electronic Center
- Omaha...Scott Electronics

NEVADA
- Las Vegas...Century 23

NEW JERSEY
- Edison...William Electronic Supply
- Fairlawn...Heathkit Electronic Center
- Mantua...Electronic World
- Ocean...Heathkit Electronic Center
- Trenton...Lafayette Radio Supply
- Vineland...Laraco/Vineland

NEW MEXICO
- Alamagordo...Basin Electronics

NEW YORK
- Albany...Greylock Electronics
- Amherst...Heathkit Electronic Center
- Buffalo...Olson Electronics
- Buffalo...Radio Equipment Corp.
- Commack...Spartan Electronics
- Hornell...Hornell Electronics
- Ithaca...Rad-Tronics
- Jamestown...Warren Radio
- Jericho...Heathkit Electronic Center
- Johnson City...Unicorn Electronics
- Kingston...Greylock Electronics
- Middleton...Greylock Electronics
- Newburgh...Action Audio Inc.
- New York...Manhattan Electronics
- New York...Taft Electronics
- Poughkeepsie...Greylock Electronics
- Rensslaer...Electronic Stockroom
- Rochester...Heathkit Electronic Center
- Seneca...Olson Electronics
- Troy...Trojan Electronic Supply
- Utica...Central Electronics
- White Plains...Computer Corner
- White Plains...Heathkit Electronic Center

NORTH CAROLINA
- Greensboro...Heathkit Electronic Center
- Winston-Salem...Trayer-Yelverton Inc.

NORTH DAKOTA
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- Fargo...S/S Electronics

OHIO
- Akron...Akron Electronic Supply
- Akron...Warren Radio
- Bucyrus...Mead Electronics
- Canton...Electronic Center Inc.
- Cincinnati...Heathkit Electronic Center
- Cleveland...Heathkit Electronic Center
- Columbus...Heathkit Electronic Center
- Columbus...Olson Electronics
- Dover...T.V. Specialties
- Lima...Warren Radio
- Massillon...M. H. Martin Co.
- Mogadore...Olson Electronics
- Parma...Superior Electronics
- Reynoldsburg...Universal Amateur Radio
- Toledo...Heathkit Electronic Center
- Toledo...Warren Radio
- Youngstown...Olson Electronics
- Youngstown...Ross Radio Co.

OKLAHOMA
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OREGON
- Albany...Oregon Ham Sales
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- Portland...Portland Radio Supply
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- Salem...Computer Specialties
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PENNSYLVANIA
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- Pittsburgh...Heathkit Electronic Center
- Pittsburgh...Pittsburgh Computer Store
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- Pittsburgh...The Computer House
- York...G.Y.C. Co.

RHODE ISLAND
- Cranston...Jabbour Electronics
- Pawtucket...Jabbour Electronics
- Providence...Hope Electronics
- Warwick...Heathkit Electronic Center

TENNESSEE
- Bristol...Shields Electronics
- Concord...National Electronics
- Cookeville...Wagnon's Stereo Center
- Dyersburg...Warren Radio
- Knoxville...Shield's Electronic Supply
- Memphis...Bluff City Electronics
- Memphis...Memphis Amateur Electronics
- Memphis...Warren Radio
- Murfreesboro...Murfreesboro Radio & Elect.
- Murfreesboro...Standard Auto Parts
- Nashville...Eddie Warne s Parts Co.
- Nashville...Electra Dist. Co.
- Oak Ridge...Mr. Radio
- Oak Ridge...National Electronics
- Smyrna...Delker Electronics
- Tullahoma...H&H Electronics

TEXAS
- Brownsville...George's Electronic Mart
- Dallas...Heathkit Electronic Center
- Enid...Trice Electronics
- Fort Worth...Heathkit Electronic Center
- Harligen...George's Electronic Mart
- Houston...Heathkit Electronic Center
- Lubbock...Trice Electronics
- McAllen...Carlos Franco Electronics
- McAllen...George's Electronic Mart
- Richardson...Martin Wholesale Electronics
- Richardson...Trice Electronics
- San Antonio...C&K Electronics
- San Antonio...Heathkit Electronic Center
- Waco...L&M Wholesale

UTAH
- Midvale...Heathkit Electronic Center
- Ogden...Carter Supply Co.
- Provo...Alpine Electronic Supply
- Salt Lake City...Best Distributing
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- Salt Lake City...Mountain Coin Distributing
- Salt Lake City...RA-ELCO Inc.

VERMONT
- Burlington...Greylock Electronics
- Essex Junction...I.E.S. Lafayette Radio

VIRGINIA
- Alexandria...Heathkit Electronic Center
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- Blacksburg...Scotty's Radio & TV
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- Harrisonburg...Electrical Wholesalers
- Hopewell...B&G Electronics
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- Pullman...H&O Electronics
- Richland...Radio Shack
- Seattle...A.B.C. Communications
- Seattle...Amateur Radio Supply
- Seattle...Electronic Supply Co.
- Seattle...Heathkit Electronic Center
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NEW!! 1984 ITEMS!

CONNECTORS AND ACCESSORIES

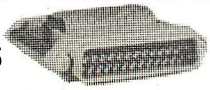
DOUBLE-ROW MALE HEADERS



• Solder to PC boards for instant plug-in access • .025" square posts on a .10" x .10" matrix

Part No.	Description
923862R	20 post double row male
923863R	26 post double row male
923864R	34 post double row male
923865R	40 post double row male
923866R	50 post double row male

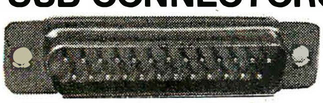
GENDER CHANGERS



Used to connect 2 cables which have the same gender.

Part No.	Description
JRSM-M	Connects 2 male (DB25P) cables
JRSF-F	Connects 2 female (DB25S) cables

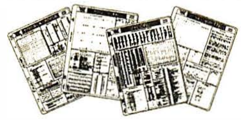
D-SUB CONNECTORS



SOLDER-TYPE CONTACTS

Part No.	Description
DE9P	9 Pin Plug
DE9S	9 Pin Socket
DE9H	Hood for DE9 Series Connectors
DA15P	15 Pin Plug
DA15S	15 Pin Socket
DA15H	Hood for DA15 Series Connectors
DB25P	25 Pin Plug (Meets RS232)
DB25S	25 Pin Socket (Meets RS232)
DB25H	Hood for DB25 Series Connectors
DC37P	37 Pin Plug
DC37S	37 Pin Socket
DC37H	Hood for DC37 Series Connectors
DD50P	50 Pin Plug
DD50S	50 Pin Socket
DD50H	Hood for DD50 Series Connectors

MICRO CHARTS

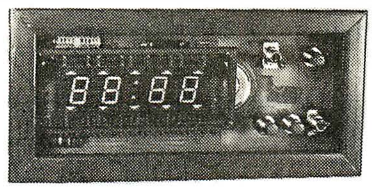


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Part No.	Description
MLZ80	Z80 CPU
ML6502	6502 (65XX)
ML7400	5400/7400 TTL Pinouts
ML8080A	8080A/8085A

JE750 4-Digit Fluorescent Alarm Clock Kit

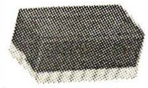


The JE750 Alarm Clock Kit is a versatile 12-hour digital clock with 24-hour alarm. The clock has a bright 0.5" high blue-green fluorescent display. The display will automatically dim with changing light conditions. The 24-hour alarm allows the user to disable the alarm and immediately re-enable the alarm to activate 24 hours later. The kit includes all documentation, case and wall transformer. Other features: flashing colon, alarm tone 500Hz once per sec., 10 minute snooze alarm, am/pm indicator. Size: 6⅝"L x 3¼"H x 1¾"D.

Part No. JE750 Kit

Insulation Displacement Connectors

Dip Plug Connectors



Part No.	Description
609-14	14 Contact Dip Plug Connector
609-16	16 Contact Dip Plug Connector
609-24	24 Contact Dip Plug Connector
609-40	40 Contact Dip Plug Connector

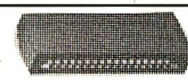
Socket Connectors



Mates 2 rows of .025" sq. dia. posts on patterns of .100" centers.

Part No.	Description
S20	20 Contact Socket Connector
S26	26 Contact Socket Connector
S34	34 Contact Socket Connector
S40	40 Contact Socket Connector
S50	50 Contact Socket Connector

Card-Edge Connectors



Mates with double-sided 1/16" PC board with contact fingers on .100" centers.

Part No.	Description
C20	20 Contact Card-Edge Connector
C26	26 Contact Card-Edge Connector
C34	34 Contact Card-Edge Connector
C40	40 Contact Card-Edge Connector
C50	50 Contact Card-Edge Connector

D-Sub Connectors



FLAT CABLE CONTACTS

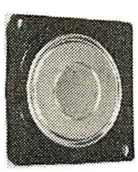
Part No.	Description
CDE9P	9 Contact Plug
CDE9S	9 Contact Socket
CDA15P	15 Contact Plug
CDA15S	15 Contact Socket
CDB25P	25 Contact Plug
CDB25S	25 Contact Socket
CDC37P	37 Contact Plug
CDC37S	37 Contact Socket

DATA BOOKS



Part No.	Description
210830	Intel Memo y
210844	Intel Microprocessor
30001	National CMOS
30003	National Linear
30005	National TTL Logic
30009	Intersil Data
30013	Zilog Microprocessor

SPEAKER



1-3/16" Square • 5/32" Thick
8 Ohm • .40 Watt

- Stainless steel diaphragm • Ultra Slim
- For alarms, music sounds, telephone equipment, computers, speech aids, etc.

Part No. TS30S

JOYSTICKS



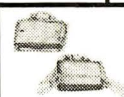


Part No.	Description
JS100K	100K Linear Taper Pots (with knob)
JS150K	150K Linear Taper Pots (with knob)
JVC-40	40K Video Controller in case (w/knob)

Jim-pak electronic components

DIODES
CRYSTALS
TRANSISTORS
SOCKETS
KITS
SWITCHES
RESISTORS
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HEAT SINKS
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TOOLS
CORDS
SOLDER
IC'S
BOOKS
CAPACITORS
and more...

CENTRONICS





⇦ Solder Type
Insulation Displacement Type ⇨

Part No.	Description
CEN36M	36 Contact Male-Insulation Displace.
CEN36F	36 Contact Female-Insulation Displace.
57-30360	36 Contact Male - Solder
57-60360	36 Contact Female - Solder

INSULATION DISPLACEMENT CABLE ASSEMBLIES





Part No.	Description
S20-36	20-pin 36" Single-End Socket
S26-36	26-pin 36" Single-End Socket
S34-36	34-pin 36" Single-End Socket
S40-36	40-pin 36" Single-End Socket
S50-36	50-pin 36" Single-End Socket
S20-6-S	20-pin 6" Double-Ended Socket
S20-18-S	20-pin 18" Double-Ended Socket
S26-18-S	26-pin 18" Double-Ended Socket
S50-18-S	50-pin 18" Double-Ended Socket
DB25P-10-P	25-pin male 10' Double-Ended Plug
DB25P-10-S	25-pin male 10' 25-pin female
CEN36M-5	36-pin Centronics 5' male
CEN36M-5-F	36-pin Centronics 5' male to female
CEN36M-5-M	36-pin Centronics 5' male to male

Circle 198 on inquiry card.

4164 64K DYNAMIC 200 NS $5.95 TMM2016 2KX8 STATIC 200 NS $4.15

STATIC RAMS

2101	256 x 4	(450ns)	1.95
5101	256 x 4	(450ns) (cmos)	3.95
2102-1	1024 x 1	(450ns)	.89
2102L-4	1024 x 1	(450ns) (LP)	.99
2102L-2	1024 x 1	(250ns) (LP)	1.49
2111	256 x 4	(450ns)	2.49
2112	256 x 4	(450ns)	2.99
2114	1024 x 4	(450ns)	8/9.95
2114-25	1024 x 4	(250ns)	8/10.95
2114L-4	1024 x 4	(450ns) (LP)	8/12.95
2114L-3	1024 x 4	(300ns) (LP)	8/13.45
2114L-2	1024 x 4	(200ns) (LP)	8/13.95
TC5514	1024 x 4	(650ns) (cmos)	2.49
TC5516	2048 x 8	(250ns) (cmos)	9.95
2147	4096 x 1	(55ns)	4.95
TMS4044-4	4096 x 1	(450ns)	3.49
TMS4044-3	4096 x 1	(300ns)	3.99
TMS4044-2	4096 x 1	(200ns)	4.49
MK4118	1024 x 8	(250ns)	9.95
TMM2016-200	2048 x 8	(200ns)	4.15
TMM2016-150	2048 x 8	(150ns)	4.95
TMM2016-100	2048 x 8	(100ns)	6.15
HM6116-4	2048 x 8	(200ns) (cmos)	4.75
HM6116-3	2048 x 8	(150ns) (cmos)	4.95
HM6116-2	2048 x 8	(120ns) (cmos)	8.95
HM6116LP-4	2048 x 8	(200ns) (cmos)(LP)	5.95
HM6116LP-3	2048 x 8	(150ns) (cmos)(LP)	6.95
HM6116LP-2	2048 x 8	(120ns) (cmos)(LP)	10.95
Z-6132	4096 x 8	(300ns) (Qstat)	34.95
HM6264	8192 x 8	(150ns) (cmos)	49.95

LP = Low Power Qstat = Quasi-Static

DYNAMIC RAMS

TMS4027	4096 x 1	(250ns)	1.99
UPD411	4096 x 1	(300ns)	3.00
MM5280	4096 x 1	(300ns)	3.00
MK4108	8192 x 1	(200ns)	1.95
MM5298	8192 x 1	(250ns)	1.85
4116-300	16384 x 1	(300ns)	8/11.75
4116-250	16384 x 1	(250ns)	8/7.95
4116-200	16384 x 1	(200ns)	8/12.95
4116-150	16384 x 1	(150ns)	8/14.95
4116-120	16384 x 1	(120ns)	8/29.95
2118	16384 x 1	(150ns) (5v)	4.95
MK4332	32768 x 1	(200ns)	9.95
4164-200	65536 x 1	(200ns) (5v)	5.95
4164-150	65536 x 1	(150ns) (5v)	6.95
MCM6665	65536 x 1	(200ns) (5v)	8.95
TMS4164-15	65536 x 1	(150ns) (5v)	8.95

5V = single 5 volt supply

EPROMS

1702	256 x 8	(1us)	4.50
2708	1024 x 8	(450ns)	3.95
2758	1024 x 8	(450ns) (5v)	5.95
2716	2048 x 8	(450ns) (5v)	3.95
2716-1	2048 x 8	(350ns) (5v)	5.95
TMS2516	2048 x 8	(450ns) (5v)	5.50
TMS2716	2048 x 8	(450ns)	7.95
TMS2532	4096 x 8	(450ns) (5v)	5.95
2732	4096 x 8	(450ns) (5v)	4.95
2732-250	4096 x 8	(250ns) (5v)	8.95
2732-200	4096 x 8	(200ns) (5v)	11.95
2732A-4	4096 x 8	(450ns) (5v) (21vPGM)	6.95
2732A	4096 x 8	(250ns) (5v) (21vPGM)	9.95
2732A-2	4096 x 8	(200ns) (5v) (21vPGM)	13.95
2764	8192 x 8	(450ns) (5v)	6.95
2764-250	8192 x 8	(250ns) (5v)	7.95
2764-200	8192 x 8	(200ns) (5v)	19.95
TMS2564	8192 x 8	(450ns) (5v)	14.95
MCM68764	8192 x 8	(450ns) (5v) (24 pin)	39.95
MCM68766	8192 x 8	(350ns) (5v) (24 pin)(pwr dn.)	42.95
27128	16384 x 8	(300ns) (5v)	29.95

5v = Single 5 Volt Supply 21vPGM = Program at 21 Volts

EPROM ERASERS

SPECTRONICS CORPORATION

	Timer	Capacity Chip	Intensity (uW/Cm²)	
PE-14		9	8,000	83.00
PE-14T	X	9	8,000	119.00
PE-24T	X	12	9,600	175.00
PL-265T	X	30	9,600	255.00
PR-125T	X	25	17,000	349.00
PR-320T	X	42	17,000	595.00

* ★ Computer managed inventory — virtually no back orders!
* ★ Very competitive prices!
* ★ Friendly staff!
* ★ Fast service — most orders shipped within 24 hours!

CRYSTALS

32.768 khz	1.95
1.0 mhz	3.95
1.8432	3.95
2.0	2.95
2.097152	2.95
2.4576	2.95
3.2768	2.95
3.579545	2.95
4.0	2.95
5.0	2.95
5.0688	2.95
5.185	2.95
5.7143	2.95
6.0	2.95
6.144	2.95
6.5536	2.95
8.0	2.95
10.0	2.95
10.738635	2.95
14.31818	2.95
15.0	2.95
16.0	2.95
17.430	2.95
18.0	2.95
18.432	2.95
20.0	2.95
22.1184	2.95
32.0	2.95

UARTS

AY3-1014	6.95
AY5-1013	3.95
AY3-1015	6.95
PT1472	9.95
TR1602	3.95
2350	9.95
2651	8.95
IM6402	7.95
IM6403	8.95
INS8250	10.95

GENERATORS

BIT-RATE

MC14411	11.95
BR1941	11.95
4702	12.95
COM5016	16.95
COM8116	10.95
MM5307	10.95

FUNCTION

MC4024	3.95
LM566	1.49
XR2206	3.75
8038	3.95

MISC.

UPD7201	29.95
TMS99532	29.95
ULN2003	2.49
3242	7.95
3341	4.95
MC3470	4.95
MC3480	9.00
11C90	13.95
95H90	7.95
2513-001 UP	9.95
2513-002 LOW	9.95

CLOCK CIRCUITS

MM5314	4.95
MM5369	3.95
MM5375	4.95
MM58167	12.95
MM58174	11.95
MSM5832	3.95

KEYBOARD CHIPS

AY5-2376	11.95
AY5-3600	11.95
AY5-3600 PRO	11.95

CMOS

4000	.29	4528	1.19
4001	.25	4531	.95
4002	.25	4532	1.95
4006	.89	4538	1.95
4007	.29	4539	1.95
4008	.95	4541	2.64
4009	.39	4543	1.19
4010	.45	4553	5.79
4011	.25	4555	.95
4012	.25	4556	.95
4013	.38	4581	1.95
4014	.79	4582	1.95
4015	.39	4584	.75
4016	.39	4585	.75
4017	.69	4702	12.95
4018	.79	74C00	.35
4019	.39	74C02	.35
4020	.75	74C04	.35
4021	.79	74C08	.35
4022	.79	74C10	.35
4023	.29	74C14	.59
4024	.65	74C20	.35
4025	.29	74C30	.35
4026	1.65	74C32	.39
4027	.45	74C42	1.29
4028	.69	74C48	1.99
4029	.79	74C73	.65
4030	.39	74C74	.65
4034	1.95	74C76	.80
4035	.85	74C83	1.95
4040	.75	74C85	1.95
4041	.75	74C86	.39
4042	.69	74C89	4.50
4043	.85	74C90	1.19
4044	.79	74C93	1.75
4046	.85	74C95	.99
4047	.95	74C107	.89
4049	.35	74C150	5.75
4050	.35	74C151	2.25
4051	.79	74C154	3.25
4053	.79	74C157	1.75
4060	.89	74C160	1.19
4066	.39	74C161	1.19
4068	.39	74C162	1.19
4069	.29	74C163	1.19
4070	.35	74C164	1.39
4071	.29	74C165	2.00
4072	.29	74C173	.79
4073	.29	74C174	1.19
4075	.29	74C175	1.19
4076	.79	74C192	1.49
4078	.29	74C193	1.49
4081	.29	74C195	1.39
4082	.29	74C200	5.75
4085	.95	74C221	1.75
4086	.95	74C244	2.25
4093	.49	74C373	2.45
4098	2.49	74C374	2.45
4099	1.95	74C901	.39
14409	12.95	74C902	.85
14410	12.95	74C903	.85
14411	11.95	74C905	10.95
14412	12.95	74C906	.95
14419	7.95	74C907	1.00
14433	14.95	74C908	2.00
4502	.95	74C909	2.75
4503	.65	74C910	9.95
4508	1.95	74C911	8.95
4510	.85	74C912	8.95
4511	.85	74C914	1.95
4512	.85	74C915	1.19
4514	1.25	74C918	2.75
4515	1.79	74C920	17.95
4516	1.55	74C921	15.95
4518	.89	74C922	4.49
4519	.39	74C923	4.95
4520	.79	74C925	5.95
4522	1.25	74C926	7.95
4526	1.25	74C928	7.95
4527	1.95	74C929	19.95

6800

68000	49.95
6800	2.95
6802	7.95
6803	19.95
6808	13.90
6809E	14.95
6809	11.95
6810	2.95
6820	4.35
6821	2.95
6828	14.95
6840	12.95
6843	34.95
6844	25.95
6845	14.95
6847	11.95
6850	3.25
6852	5.75
6860	7.95
6875	6.95
6880	2.25
6883	22.95
68047	24.95
68488	19.95

6800 = 1MHZ

68B00	10.95
68B02	22.25
68B09E	29.95
68B09	29.95
68B10	6.95
68B21	6.95
68B40	19.95
68B45	19.95
68B50	5.95

68B00 = 2 MHZ

6500

1 MHZ

6502	4.95
6504	6.95
6505	8.95
6507	9.95
6520	4.35
6522	6.95
6532	9.95
6545	22.50
6551	11.85

2 MHZ

6502A	6.95
6522A	9.95
6532A	11.95
6545A	27.95
6551A	11.95

3 MHZ

6502B	9.95

DISC CONTROLLERS

1771	16.95
1791	24.95
1793	26.95
1795	29.95
1797	49.95
2791	54.95
2793	54.95
2795	59.95
2797	59.95
6843	34.95
8272	39.95
UPD765	39.95
MB8876	29.95
MB8877	34.95
1691	17.95
2143	18.95

8000

8035	5.95
8039	5.95
INS-8060	17.95
INS-8073	49.95
8080	3.95
8085	4.95
8085A-2	11.95
8086	24.95
8087	CALL
8088	29.95
8089	89.95
8155	6.95
8155-2	7.95
8156	6.95
8185	29.95
8185-2	39.95
8741	29.95
8748	24.95
8755	24.95

CRT CONTROLLERS

6845	14.95
68B45	19.95
HD46505SP	15.95
6847	11.95
MC1372	6.95
68047	24.95
8275	29.95
7220	99.95
CRT5027	19.95
CRT5037	24.95
TMS9918A	39.95
DP8350	49.95

8200

8202	24.95
8203	39.95
8205	3.50
8212	1.80
8214	3.85
8216	1.75
8224	2.25
8226	1.80
8228	3.49
8237	19.95
8237-5	21.95
8238	4.49
8243	4.45
8250	10.95
8251	4.49
8253	6.95
8253-5	7.95
8255	4.49
8255-5	5.25
8257	7.95
8257-5	8.95
8259	6.90
8259-5	7.50
8271	79.95
8272	39.95
8275	29.95
8279	8.95
8279-5	10.00
8282	6.50
8283	6.50
8284	5.50
8286	6.50
8287	6.50
8288	25.00
8289	49.95

Z-80

2.5 Mhz

Z80-CPU	3.95
Z80-CTC	3.95
Z80-DART	10.95
Z80-DMA	14.95
Z80-PIO	3.95
Z80-SIO/0	11.95
Z80-SIO/1	11.95
Z80-SIO/2	11.95
Z80-SIO/9	11.95

4.0 Mhz

Z80A-CPU	4.49
Z80A-CTC	4.95
Z80A-DART	9.95
Z80A-DMA	12.95
Z80A-PIO	4.49
Z80A-SIO/0	12.95
Z80A-SIO/1	12.95
Z80A-SIO/2	12.95
Z80A-SIO/9	12.95

6.0 Mhz

Z80B-CPU	9.95
Z80B-CTC	12.95
Z80B-PIO	12.95
Z80B-DART	19.95
Z80B-SIO/2	39.95

ZILOG

Z6132	34.95
Z8671	39.95

JDR Microdevices

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TERMS: Minimum order $10. For shipping and handling include $2.50 for UPS Ground and $3.50 for UPS Air. Orders over 1 lb. and foreign orders may require additional shipping charges — please contact our sales department for the amount. CA residents must include 6% sales tax, Bay Area and LA residents include 6½%. Prices subject to change without notice. We are not responsible for typographical errors. We reserve the right to limit quantities and to substitute manufacturer. All merchandise subject to prior sale.

Circle 195 on inquiry card.

Circle 196 on inquiry card.

2732 32K EPROM $4.95

2764 64K EPROM $6.95

MICROCOMPUTER HARDWARE HANDBOOK
FROM ELCOMP — $14.95

Over 800 pages of manufacturers data sheets on most commonly used IC's.

Includes:
- ★ TTL — 74/74LS and 74F
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- ★ Memory — RAM, ROM, EPROM
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- ★ MPU support & interface — 6800, 6500, Z80, 8200, etc.

DISK DRIVES

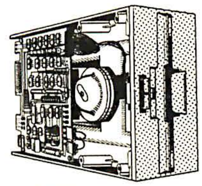
TANDON
TM100-1 5¼" (FOR IBM) SS/DD	229.00
TM100-2 5¼" (FOR IBM) DS/DD	259.00

SHUGART
SA 400L 5¼" (40 TRACK) SS/DD	199.95
SA 400 5¼" (35 TRACK) SS/DD	189.95

PERTEC
FD-200 5¼" SS/DD	179.95
FD-250 5¼" DS/DD	199.95

MPI
MP-52 5¼" (FOR IBM) DS/DD	249.00

NOTE: Please include sufficient amount for shipping on above items.



8-INCH DISK DRIVE SALE

FD 100-8
SHUGART 801 EQUIV.
SS/DD — 10/$175 EA.
$189.00

FD 200-8
SHUGART 851 EQUIV.
DS/DD — 10/$220 EA.
$239.00

BEST SELLING BOOKS

OSBORNE/MC GRAW-HILL
Apple II User's Guide	16.95
CRT Controller's Handbook	9.95
68000 Assembly Language Programming	16.99
CBASIC User Guide	15.00

SYBEX
Your First Computer	8.95
The CP/M Handbook	14.95
The PASCAL Handbook	18.95
Microprocessor Interfacing Techniques	17.95

EDGE-CARD CONNECTORS
S-100 ST	3.95
S-100 WW	4.95
72 pin ST	6.95
72 pin WW	7.95
50 pin ST	4.95
44 pin ST	2.95
44 pin WW	4.95

CABINETS FOR 5¼" DISK DRIVES

CABINET #1 $29.95
- ★ DIMENSIONS 8⅝ x 515/16 x 3 15/16"
- ★ COLOR MATCHES APPLE
- ★ FITS STANDARD 5¼" DRIVES, INCL. SHUGART
- ★ INCLUDES MOUNTING HARDWARE AND FEET

NOTE: Please include sufficient amount for shipping on above items.

CABINET #2 $79.00
- ★ COMPLETE WITH POWER SUPPLY, SWITCH, LINE CORD, FUSE & STANDARD POWER CONNECTOR
- ★ DIMENSIONS: 11½ x 5¾ x 3 15/16"
- ★ +5V @ 1 AMP, +12V @ 1.5 AMP
- ★ FITS STANDARD 5¼" DRIVES
- ★ PLEASE **SPECIFY** GRAY OR TAN

TRANSFORMERS

FRAME STYLE
12.6VAC	2amp	4.95
12.6VAC CT	2amp	5.95
12.6VAC CT	4amp	7.95
12.6VAC CT	8amp	10.95
25.2VAC CT	2amp	7.95

PLUG CASE STYLE
12VAC	250ma	3.95
12VAC	500ma	4.95
12VAC	1amp	5.95
12VAC	2amp	6.95

DC ADAPATER
6, 9, 12 VDC selectable with universal adapter 8.95

NOTE: Please include sufficient amount for shipping on above items.

VISIT DURING OUR EXPANDED RETAIL STORE HOURS SATURDAY 10 to 3

CENTRONICS
IDCEN36	Ribbon Cable	36 Pin Male	8.95
IDCEN36/F	Ribbon Cable	36 Pin Female	8.95
CEN36	Solder Cup	36 Pin Male	7.95

DIP CONNECTORS
DESCRIPTION	HIGH RELIABILITY TOOLED ST IC SOCKETS	COMPONENT CARRIERS (DIP HEADERS)	RIBBON CABLE DIP PLUGS (IDC)
ORDER BY	AUGATxx-ST	ICCxx	IDPxx
CONTACTS 8	.99	.65	
14	.99	.75	1.45
16	.99	.85	1.65
18	1.69	1.00	
20	1.89	1.25	
22	1.89	1.25	
24	1.99	1.35	2.50
28	2.49	1.50	
40	2.99	2.10	4.15

For order instructions see "IDC Connectors" below.

RIBBON CABLE
CONTACTS	SINGLE COLOR 1'	SINGLE COLOR 10'	COLOR CODED 1'	COLOR CODED 10'
10	.50	4.40	.83	7.30
16	.55	4.80	1.00	8.80
20	.65	5.70	1.25	11.00
25	.75	6.60	1.32	11.60
26	.75	6.60	1.32	11.60
34	.98	8.60	1.65	14.50
40	1.32	11.60	1.92	16.80
50	1.38	12.10	2.50	22.00

D-SUBMINIATURE
DESCRIPTION	SOLDER CUP MALE	SOLDER CUP FEMALE	RIGHT ANGLE PC SOLDER MALE	RIGHT ANGLE PC SOLDER FEMALE	IDC RIBBON CABLE MALE	IDC RIBBON CABLE FEMALE	HOODS BLACK	HOODS GREY
ORDER BY	DBxxP	DBxxS	DBxxPR	DBxxSR	IDBxxP	IDBxxS	HOOD-B	HOOD
CONTACTS 9	2.08	2.66	1.65	2.18	3.37	3.69	---	1.60
15	2.69	3.63	2.20	3.03	4.70	5.13	---	1.60
25	2.50	3.25	3.00	4.42	6.23	6.84	1.25	1.25
37	4.80	7.11	4.83	6.19	9.22	10.08	---	2.95
50	6.06	9.24	---	---	---	---	---	3.50

For order instructions see "IDC Connectors" below.

MOUNTING HARDWARE 1.00

IDC CONNECTORS
DESCRIPTION	SOLDER HEADER	RIGHT ANGLE SOLDER HEADER	WW HEADER	RIGHT ANGLE WW HEADER	RIBBON HEADER SOCKET	RIBBON HEADER	RIBBON EDGE CARD
ORDER BY	IDHxxS	IDHxxSR	IDHxxW	IDHxxWR	IDSxx	IDMxx	IDExx
CONTACTS 10	.82	.85	1.86	2.05	1.15	---	2.25
20	1.29	1.35	2.98	3.28	1.86	5.50	2.36
26	1.68	1.76	3.84	4.22	2.43	6.25	2.65
34	2.20	2.31	4.50	4.45	3.15	7.00	3.25
40	2.58	2.72	5.28	4.80	3.73	7.50	3.80
50	3.24	3.39	6.63	7.30	4.65	8.50	4.74

ORDERING INSTRUCTIONS: Insert the number of contacts in the position marked "**xx**" of the "order by" part number listed. **Example:** A 10 pin right angle solder style header would be IDH**10**SR.

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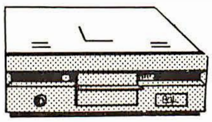
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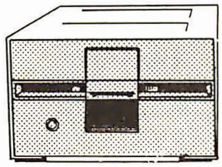
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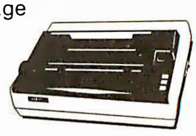
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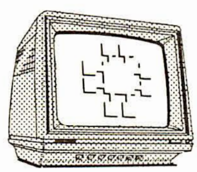
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Circle 197 on inquiry card.

Unclassified Ads

WANTED: The Association of Radio Reading Services (ARRS) Inc., an organization representing stations that provide radio broadcasts to the blind and handicapped, seeks tax-deductible TRS-80 Model III or 4. We offer receipt; will pay shipping. Kent Bowers, Treasurer, ARRS, 1108 Northeast 36th St., Oklahoma City, OK 73111, (405) 521-3514.

WANTED: Established, nonprofit educational institution seeks tax-deductible gifts of microcomputer, disk drives, monitor and printer. Will pay shipping. Mary Kane Trochim, Community School of Music and Arts, Whiton House, Ithaca, NY 14850, (607) 272-1474.

WANTED: Historic Hudson River church seeks tax-deductible donation of old but functioning personal or small business system for our name list, WP, accounts, etc. We would be happy with almost any disk-based system, such as CP/M, Apple, TRS-80 Models II or III, etc. Christ Church, Elizabeth St., Tarrytown, NY 10591, (914) 631-9194.

WANTED: Newly formed computer club in Philippines seeks correspondence with user's group in America to exchange information on software utilities and applications. Dbrs. Mario Franco Arroyo, 14-D La Salle St., Cubao, Quezon City, Philippines.

WANTED: Herbal Investigation of Pharmacology is a computer club seeking to share information and software about botanical medicine. Herbal Investigation of Pharmacology, 2509 North Campbell #9, Tucson, AZ 85719.

NEEDED: Nonprofit appropriate-technology organization in a developing country needs technical, engineering, health service, and bibliographical software for use in Apple/Corvus/Condor system. Botswana Technology Centre, Private Bag 0082, Gaborone, Botswana, Southern Africa.

FOR SALE: Cromemco C-10 with two disk drives and software: $1000. Jim O'Toole, 422 South Las Palmas Ave., Los Angeles, CA 90020, (213) 933-9806.

FOR TRADE: Unopened Ashton-Tate and *Base II for* Osborne 1. Will trade for printer in good condition or $350. Gary Watson, R. 1, 903 East Mason Rd., Milan, OH 44846, (419) 499-2063.

WANTED: Computers, peripherals, parts, etc. in hopes that I can put together a working system. I will gratefully accept anything; especially interested in DEC or DG minis. Will pay for postage. Bill Donnelly, POB 1978, Oroville, CA 95965.

FOR SALE: Magic Wand. Doesn't work with my operating system. Only slightly used. Will sell for $120. Br. Brian Kerns, Abbey of the Genesee, Piffard, NY 14533, (716) 243-0660.

WANTED: Parts lists and IC numbers for Redactron (mfg. 1970s) (CPU console) Word Processor with two cassette drives and IBM Selectric #745 I/O. Quote or send and will reimburse. D. Teste, Box 9064, Newark, NJ 07104.

FOR TRADE: Want to swap programs for Apple II Plus. Send your list of programs or games and I'll send mine. Koon-Ping Tong, POB 16274, San Francisco, CA 94116.

WANTED: The Twin City TRS-80 User Group (TCTUG) is seeking to exchange public-domain programs with other groups or individuals. We accept any TRS-80 disk or tape format but prefer TRSDOS 1.3 format. We will return your disk with programs from our library. TCTUG Library, Gary Schlegel, 21581 Creekside Circle, Lakeville, MN 55044.

FOR SALE: Hewlett-Packard HP-85A with 5¼-inch dual master flexible disk drive, 32K memory, advanced programming ROM, Assembler ROM, and other required hardware. John L. Brown, 66 Orange St., Brooklyn, NY 11201, (212) 834-9244.

FOR SALE: Sources for: BIOS for CP/M 2.2 on Corvus hard disk and dual floppy for CCS 2210; MP/M II XIOS for systems group 2810; MPM/II XIOS for CCS 2210 floppy-disk system. All MP/M XIOS include LDRBIOS, RESXIOS, and BNKXIOS supplied on 8-inch, single-density floppy disk: $100 each. Steve Mastrianni, Box 216B, Vernon, CT 06066.

FOR TRADE: Programs for Apple II Plus. Send your list of programs and I will send mine. Roland Forsman, 51 Tower Rd., Brookfield, CT 06805.

FOR SALE: STD BUS Z80 CP/M computers with 16-slot card cage, CPU card, two serial I/Os, four parallel I/Os, hefty power supply, steel cabinet with locking door, all brand name equipment, documentation, guaranteed: $495. STD BUS 16K EPROM cards with eight 2716 EPROMS: $55. 8-inch disk drive with enclosure and power: $150. 5¼-inch disk drive Shugart SA-400: $49. L. H. Gary, 6111 Edgerton Dr., Greensboro, NC 27410, (919) 852-6806 evenings.

FOR SALE: 64K Micro Profesor. Seven program and joysticks included. Has Apple and block graphics, one key basic commands, and accepts programs on tape (cable included). Monitor requires no interface. Cartridges and interfaces for printers and disk drives available. Asking $395. Francis Hsu, 42-11 149 PL, Flushing, NY 11355, (212) 939-2491.

FOR SALE: Heath IM-4180 FM-deviation meter: $100. Heath ET-3300B breadboard: $65. Heath BASIC Programming course: $25. Analyzer: $40. Voltmeter: $100. Amplifier: $40. HDOS 2.0: $75. IMSAI motherboard: $75. EconoRAM II: $50. Multi I/O board: $50. Keyboard: $25. Will trade some for H-89 accessories. Jack Ball, Rt. 2, Box 330, Durham, MO 63438.

FOR SALE: Apple interface cards in language, Integer, FORTH, 16K RAM, CP/M, disk, Epson printer: $50 each. 80-column (Videx type): $80 each. Printer buffers 16K/32K/64K: $90/$100/$120. Our expatriate engineer's computer club is upgrading to IBM compatibles and we have many Apple compatible accessories available. Include $5 per card for shipping; personal checks OK. Jimmy Menning, 36-90 Da Pei Rd., Kaohsiung 833, Taiwan, Republic of China.

FOR SALE: Atari 800, 48K; dual DSDD Percom drives, 352K each; Atari 850 interface (four serial and parallel); Mannesmann Tally MT160L printer, 160 cps; and two WICO BOSS joysticks. Software includes OS/A+ DOS. All necessary cables and supplies: $2300 or best offer, or will trade for IBM PC. David Hayes, 92 25th St., Troy, NY 12180, (518) 271-0709 evenings.

WANTED: Used Apple II Plus with Disk II Drive (DOS 3.3) printer and CRT. M. Evangelista, 11128 East Canyon Meadows Dr., Whittier, CA 90601, (213) 627-1642 days and 692-2618 evenings.

FOR SALE: MC68000 single-board computer (OB68K1) by Omnibyte with 128 kilobytes of memory, IEEE-796 Multibus with documentation. Originally $1900; selling for $1100. TRS-80 Model III 48K RAM with cassette and green screen, plus many programs and books: $650. J. Creed, 5 Belaire Court, Old Bridge, NJ 08857, (201) 679-8462.

FOR SALE: BYTE 1976 through 1979. Also, many Kilobaud Microcomputing, '68 Micro Journals, dr dobbs journals, etc. Make offer. G. W. March, 2110 Country Club Parkway SE, Cedar Rapids, IA 52403.

FOR SALE: BYTE vol. 1, no. 1 through January 1978 (have 2 sets). Many are still in original wrappers. Also, Kilobaud issues no. 1 to 5. All or any part at reasonable prices. Chuck Markham, 362 Commonwealth Ave. #2E, Boston, MA 02115.

NEEDED: I am starting an Adventurer's Club for all computer owners interested in playing adventures or in writing their own. One purpose will be to exchange new adventure program listings through publication in a monthly newsletter. Maurice Dow, 84 Camberley Cres., Brampton, Ontario L6V 3L4, Canada.

FOR SALE: TRS-80 Model I with 48K expansion interface, video monitor, four external disk drives, line printer, cables, system desk, and printer stand. Fully operational: $1900. Scott Wilson, 71 Jane St., Roslyn, NY 11577, (516) 621-3000.

FOR SALE: Netronics Explorer-85 with 4K RAM and MS-BASIC in ROM with two S-100 slots and RS-232C: $250. Netronics terminal; 64 by 16 with graphics and internal power supply: $150, both for only $350. Centronics 779 printer (if wanted, cable for Exp-85): $300. Colin Cook, 8112 Ravinia Rd., Ft. Wayne, IN 46825, (219) 489-9401.

FOR SALE: S-100 boards. SD Systems ExpandoRAM II with 16K memory: $200. Ithaca Audio Z80 CPU: $80. SSM VB1-B video interface: $75. SSM MB6B 8K static memory: $65. SSM 104 I/O board: $80. Tarbell cassette interface: $60. Jade Double D disk controller: $200. Wameco Mem-1A 8K static memory: $65. Wameco QMB-12 12-slot motherboard with connectors: $50. MPI B52 5¼-inch 2-sided disk drive: $200. Bruce Kabernagel, 2047 Finch Dr., Bensalem, PA 19020, (609) 338-3226 days.

WANTED: Apple programs for trade. Please send a list of your games, utilities, etc., and I will send you a list of my extensive software collection. David Sterner, 1281 Biafore Ave., Bethlehem, PA 18017.

FOR SALE: Complete AIM-65, BASIC, Assembler, 4K RAM, and documentation with heavy-duty power supply: $200 or best offer. David Allen, 184 Avenue A #2, NY, NY 10009, (212) 673-5055.

WANTED: Atari users to buy, sell, or trade software. I have everything made for the Atari PC. Paul Hornung, 104 South 22nd St., La Crosse, WI 54601, (608) 785-2904.

FOR SALE: LNW80 computer board, Z80A processor, has 480 by 192 color resolution, TRS-80 compatible, needs two sockets repaired, all schematics and manuals are included. I have a Commodore 64, and I will trade for hardware or software, etc. Was $1995, asking $350. Jeff Fandl, Box 362, Highland Rd., Orefield, PA 18069, (215) 395-9857.

FOR SALE: Zenith Z-89 with 64K RAM, 10-megabyte hard disk and 8-inch DSDD floppy. Software includes CP/M 2.2, MBASIC (interpreter and compiler), Wordstar, FORTRAN, COBOL, and communications program. Excellent condition: $3200 or best offer. R. DeTeresa, 155-18 Locke Ave., Whitestone, NY 11357, (212) 767-1944 evenings, 430-2051 days.

WANTED: Information on computer phreak boards and their numbers. Also, want to trade lode-runner data disks (include postage if trading disks). Eric Kinney, Rt. 1 Box 136, Walla Walla, WA 99362, (509) 525-5887.

WANTED: I have a collection of cassette programs for the TRS-80 Model III. I am interested in swapping games, utilities, and home programs. Also, I am looking for people interested in corresponding. Paulo Pires, Caixa Postal 6125, 13.100, Capinas, SP, Brazil.

FOR SALE: SD Systems 256K 150 ns EXIII: $600. New MPC-4: $400. New MPMII: $300. New SA1002 5-megabyte hard disk: $500. Must sell at asking price or highest bid. Mark E. Hatch, 3961 West 8010 South, West Jordan, UT 84084, (801) 569-1266.

FOR SALE: Four electrical surge protectors to save your data from glitches, and even rfi. All new with warranty, never used: $35 each or all four for $120. Free shipping. Joseph Cross, POB 3633, Langley Park, MD 20787.

FOR TRADE: Apple games and utilities. I have large list of programs. Please send SASE. Kris Vogelsong, 1108 Kathryn St., Boalsburg, PA 16827.

WANTED: Names, addresses, prices, and information about computer camps or courses near or far for my family. Include description of your experience; would appreciate all information. Matt Beha, 6390 Cheshire, Dimondale, MI 48821.

WANTED: CP/M 2.2 operating system or later version from authorized dealer with BIOS configured for the Sharp PC-3201 with 32K ROM BASIC, 64K RAM plus 48K RAM expansion, two 8-inch DSDD drives, 77 tracks, 26 sectors, cassette interface, and Epson MX-80 serial printer. The CRT display has 80 columns, 25 lines, and is memory mapped. Also, seek correspondence with users of Sharp PC-3201s. Irene Davis, Hamburgo 330-C, Santiago, Chile, South America.

WANTED: Old computer parts, components, and equipment for educational displays. Need not be working! Especially want parts of 1st to 3rd generation computers. Also, items from silicon-chip design and manufacture. Send list of equipment with details and asking price. Jackie Seppy, 19216 Wootton Ave., Poolesville, MD 20837.

WANTED: Anyone interested in starting a users group for the Epson QX-10 is welcome to contact Patric Lee Howley, 454 Barcelona Dr., Satsuma, AL 36572.

FOR SALE: IBM-PC game board, like new: $35. Also, a Tandon 160K single-sided drive removed from my PC: $130. George Hurlbut, 1088 Alderbrook Lane, San Jose, CA 95129, (408) 252-0398.

FOR SALE: Buy my (hopelessly broken) MX70 printer for $25 or I will pay you $25 for your hopelessly broken MX70. Bob Wiseman, 1899 Muskegon Dr., Cincinnati, OH 45230, (513) 474-3546.

WANTED: Bytewriter or similar daisy-wheel printer. High school student setting up word-processing system. Will consider any reasonably priced, used, and working printer and/or system. Jason Bender, 23855 Southeast 162nd, Issaquah, WA 98027, (206) 392-2698.

FOR SALE: Digital Group System complete 64K Z80 system with two 8-inch SSDD disks, communications board, plus lots of software: $1400 or best offer. Extra 8-inch SSDD Shugart disk drive: $125. Disk controller: $100. Votrax board: $200. Three 8K memory boards: $40 each. 6800, 6502, and 8080 CPU cards not completely populated: $25 each. Over 20 original software tapes available and more. All prices are negotiable. Allan Cole, 4758 Fox Hunt Trail, Boca Raton, FL 33431, (305) 994-3535.

FOR SALE: Vector 20-slot mainframe, Microbyte Z80 card (Dart-Parallel I/O), SD Sales ExpandoRAM II with 64K, IMSAI 8-inch dual disk subsystem (IMSAI DIO-C disk controller), SSM I/O 4B: $1500 or best offer. TV910 (brand new): $575 and Epson MX80: $475. Plus, lots of software. Michael D. Reeves, 6432 Alta Vista Dr., Fort Worth, TX 76148, (817) 498-9020 evenings.

WANTED: TRS-80 Model I owners to trade software. Need Pascal/FORTRAN compilers, DOSs (NEWDOS80), and arcade games. I have many programs. Send your programs on single density, 35-track disks with DOS and I'll do the same. Also want coin-inventory programs. G. Schofer, 903 Nora Dr., Silver Spring, MD 20904.

FOR SALE: Zenith Z-100 complete system 8/16 bit with two DS/DD drives and TPI printer. Lots of software including word processing, spreadsheet, database, high level, and interpretive languages. First $3000 takes all. Mario Toscano, Bldg. 877 Apt. 602, Governors Island, NY 10004, (212) 825-0150.

FOR SALE: Timex/Sinclair 1000 including complete training course: $1000. Will consider trade. L. Miller, POB 8183, Rockville, MD 20856, (301) 251-8670.

UNCLASSIFIED POLICY: Readers who have computer equipment to buy, sell, or trade or who are requesting or giving advice may send a notice to BYTE for inclusion in the Unclassified Ads section. To be considered for publication, an advertisement must be noncommercial (individuals or bona fide computer clubs only), typed double-spaced on plain white paper, contain 75 words or less, and include complete name and address. This service is free of charge; notices are printed once only as space permits. Your confirmation of placement is appearance in an issue of BYTE as we engage in no correspondence. Please allow at least three months for your ad to appear. Send your notices to Unclassified Ads, BYTE/McGraw-Hill, POB 372, Hancock, NH 03449.

Unclassified Ads

FOR SALE: Altair 680 with 16K, three I/O, and two each Meca stand-alone RS-232 cassette drives, Micon portable RS-232 terminal, 1 by 32 LED display. Sanyo DMC-6013 color CRT, Hewlett-Packard 5036A Micro-lab, Tektronix 221 portable oscilloscope, Heathkit 6800 Micro-trainer with course and HW-8 with P/S, Cromemco SCC CPU, S-100, and OSI bare boards. B. Pinkerton, Box 2439, Melbourne, FL 32902.

FOR SALE: TRS-80 Model I 16K Level II BASIC computer, good condition, includes CTR-80 cassette deck, and the standard Radio Shack monitor. Must sell, asking $400; will accept any other reasonable offer. Dan Durachko, 102 Hartranft, University Park, PA 16802, (814) 865-8768.

FOR SALE: Apple II Plus-compatible 48K Syscom Computer with 16K Apple language card, RF modulator, disk-controller card (3.2 or 3.3), Rana Elite I disk drive, and ten disks of software (home finance, utilities, games, etc.). All in super condition: $1050 takes it. (COD OK with $100 down payment.) M. C. Smalley, 4793 Gratiot, Saginaw, MI 48603, (517) 791-1233.

WANTED: A Commodore 4040 dual-disk drive. Also, an interface that will let me run a Commodore 64 with a 4040 dual-disk drive (or a 2031 single-disk drive) and a Commodore 4022 printer. Also, numerous Commodore programs for sale. Melvin Billik, 412 Hollybrook Dr., Midland, MI 48640, (517) 631-7607.

FOR SALE: TRS-80 Model I 48K with expansion interface, monitor, lowercase, double-density "flippy" disk drive, LNdoubler, RS-232C, power-line filter, sound interface, joystick, gold plugs, NEWDOS/80, FORTRAN compiler, mu-Math, ICL, Superterm, 30 purchased cassettes, 20 disks, plus much more. Asking $1300 but will take any reasonable offer. Phil Irey, 102 Hartranft Hall, University Park, PA 16802, (814) 865-8768.

FOR SALE: Racal-Vadic 1200-bps modem, Model VA 1250, 55 P/S/G. Great buy, but half-duplex and uses Bell or Western Electric 202, the original rare protocol or computer interface: $91 or best offer. Adam Sundor, 4537 Osage Ave., Philadelphia, PA 19143, (215) 748-6463.

FOR TRADE: Apple owners including Microsoft CP/M. Send (air mail) me a list of your software, and I will send mine in exchange. R. Z. Nielson, ARAMCO, POB 4750, Ras Tanura, Via Dhahran, Saudi Arabia.

NEEDED: Word-processing success stories sought by writer. Especially looking for form letters you've written that cut bureaucratic red tape, get jobs, settle grievances, etc. I'll call you. Hugh Deadwyler, POB 419, Newell, NC 28126.

FOR TRADE: Many programs for the Apple available. Send a list of your software and a telephone number. I will send you a list of my software a week before I call you. Eric Podell, 4218 B Guilford Dr., College Park, MD 20740, (301) 779-8543.

FOR SALE: Complete collection of BYTE starting with issue #1 to December 1982. Most in mint condition. Prefer to sell as one unit. Best offer plus shipping. Bob Mitchell, 721 Glenhaven Court, Boulder, CO 80303.

WANTED: Used Apple II or compatible in working order. Send list of components with price. Walt Burkhardt, 12 Azenberg, D-7000 Stuttgart 1, West Germany, tel: 1-49-711-207-8391.

FOR SALE: Digital Group 64K system, Z80, six 4-port parallel boards, two Phi Deck controller boards, six Phi Deck drives, Digital Group floppy controller board, Deckmon and Phimon operating systems, and all kinds of documentation and software. I will pay all shipping. No reasonable offer refused. Mel Hagen, (303) 666-6536.

FOR SALE: New DT-8 DSDD disk drive: $295. New Godbout Interfacer 3-8 with warranty card: $395. DC Hayes S-100 modem: $125. R. Van Cleave, 256 South Tucson Circle, Aurora, CO 80012, (303) 340-2955.

WANTED: I am interested in exchanging software and ideas with owners of TRS-80 Color Computers, VIC-20s, and Commodore 64s. Send a list of your programs and I'll send a list of mine. John Van Gorp, Box 15, Ile des Chenes, Manitoba R0A 0T0, Canada.

FOR SALE: VIC-1600 modem for use with the Commodore 64 or VIC-20. I have the terminal program in disk and cassette. Will sell with ($50) or without ($45) Compuserve hour. Kevin Rudolph, 7811 Candle Lane, Houston, TX 77071, (713) 778-9973.

FOR TRADE: Zenith Z-100 programs. Send a list or disk of yours and I'll send the same. Nathan Gaffaney, 109 Maple St. Apt. 2, Potsdam, NY 13676.

WANTED: To trade Apple games and utilities programs. Send me a list or disk of your better programs and I'll send you a list or disk of mine. Greg Benfer, 805 Crestview Rd., Mifflinburg, PA 17844, (717) 966-0372.

WANTED: Have SOL-20 programs, will trade. Or if you own a Processor Technology SOL-20, please contact me. I have names and addresses of many SOL owners anxious to trade and talk. Robert Heerdink, 500 Redbud Dr., Forney, TX 75126.

FOR SALE: SwTPC 6800 motherboard and box, MP-A2, 20K RAM, three MPL cards, two MP-S cards, DC-2 disk controller, AC30, two MP-A, motherboard, MP-M. Also, Heath H-89, 64K, Z67 10-megabyte disk, CP/M, COBOL, BASIC, DS180, printer power/surge projector. Luke Shepherd, 5801 Sagebrush Trail, Greensboro, NC 27409, (919) 855-0108.

BOMB
BYTE's Ongoing Monitor Box

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1983's Last Tally

Steve Ciarcia won first place and $100 with "Keep Power-Line Pollution Out of Your Computer." The second-place winner is Jerry Pournelle with the User's Column, "Buddy, Can You Spare a Door Latch?" Dr. Pournelle wins the $50 bonus. In third place is Sam Edwards's "Why Is Software So Hard to Use?" Mark Haas's review of the Texas Instruments Professional Computer scored a close fourth and in fifth place is the BYTE West Coast report on Microsoft Windows, written by managing editor Phil Lemmons. Hats off to these authors.

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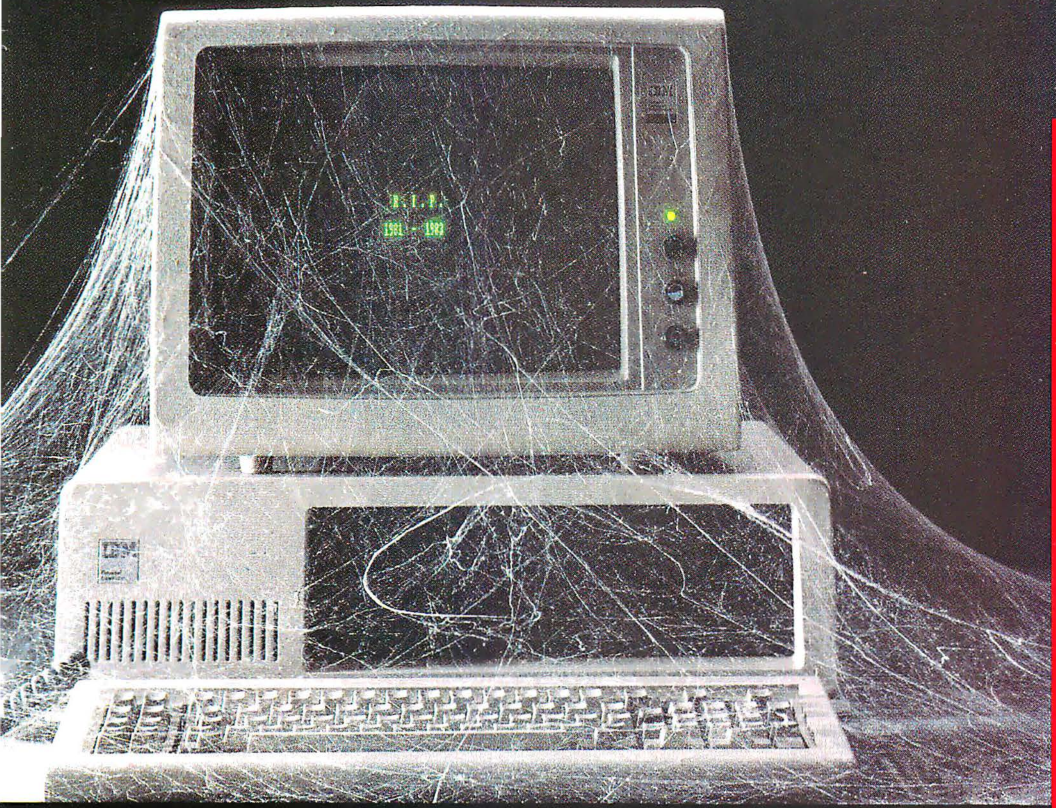
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